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A JOURNAL DEVOTED TO THE NATURAL HISTORY OF VIRGINIA

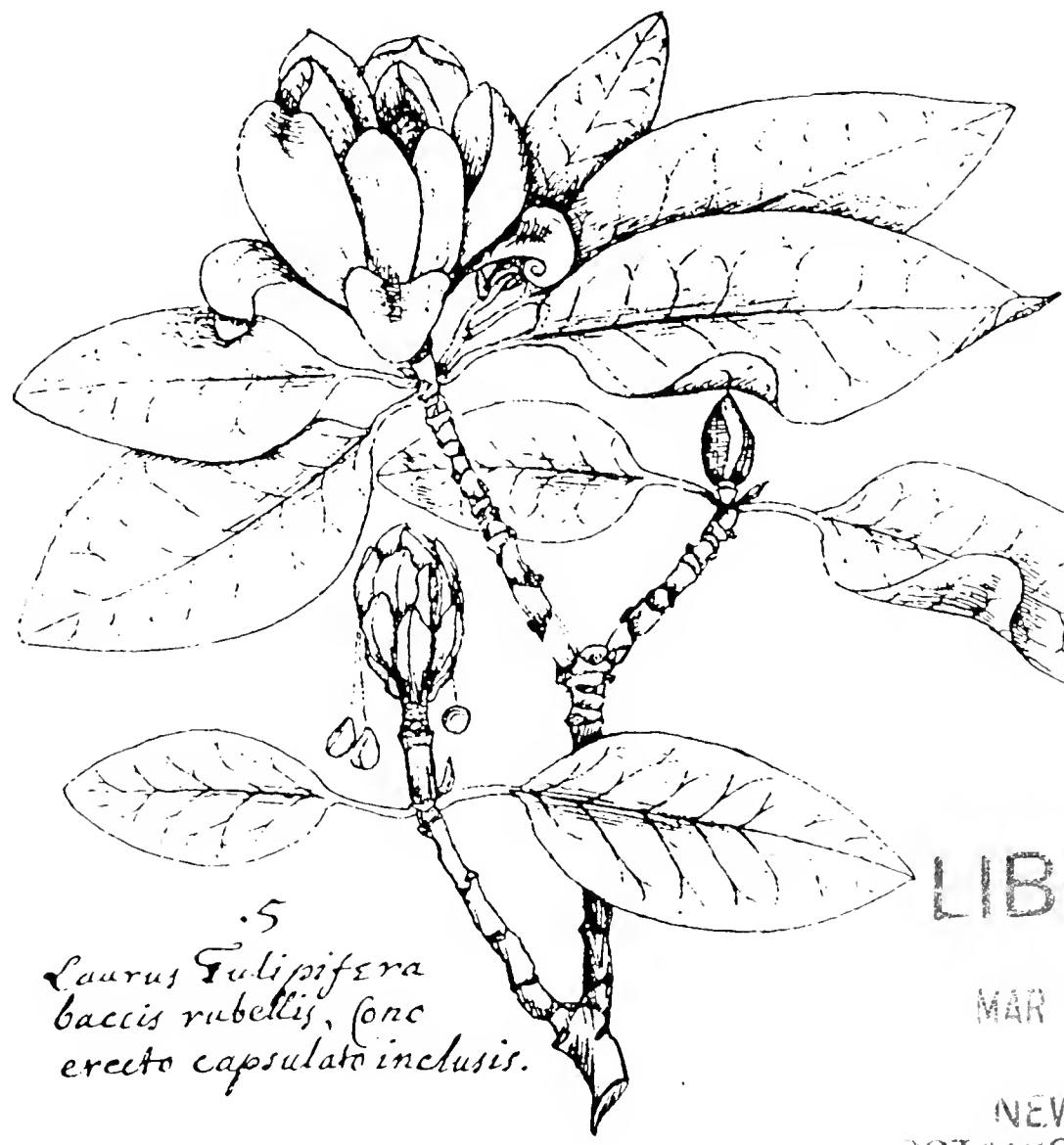

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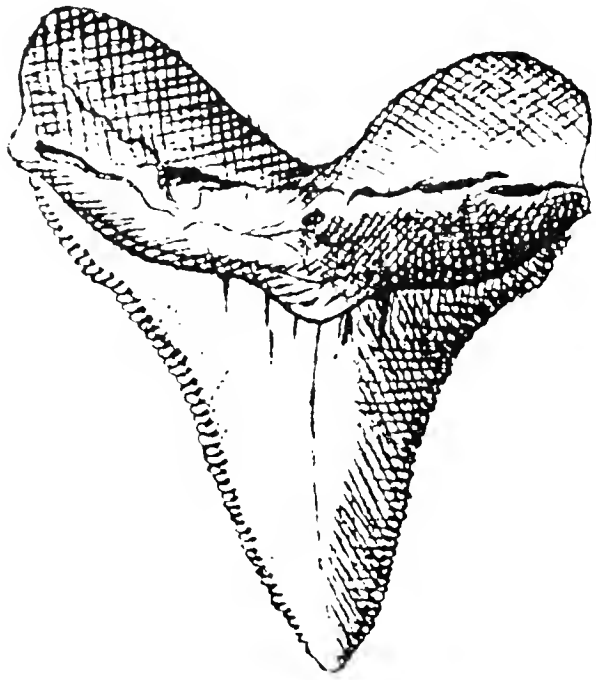
Table of Contents



Banisteria, Number 3, 1994

Survey of the Freshwater Mussel Fauna of the Powell River, Virginia

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INTRODUCTION

The Powell River, in Lee and Wise counties, Virginia supported an abundant and diverse freshwater mussel fauna. Ortmann (1918) reported 41 species of freshwater mussels from the Powell River, but predicted the eventual decline of mussel populations from human impacts. As judged by recent reports of declines in density and species richness of mussels (Ahlstedt & Brown, 1979; Neves et al., 1980; Dennis, 1981; Ahlstedt, 1986; Jenkinson & Ahlstedt, 1988), his prophecy has been realized. Environmental degradation from coal mining has been implicated as a cause of mussel declines in the last two decades (Ahlstedt & Brown, 1979; Neves et al., 1980; Dennis, 1981; Ahlstedt, 1986; Jenkinson & Ahlstedt, 1988). In the early 1980's, the full length of the Powell River was reported to run black with coal fines on occasion (Ahlstedt, 1986). In 1983 a die-off of mussels was reported from Powell River Mile (PRM) 67.0 to 143.0 and continued at least until 1986 (Ahlstedt & Jenkinson, 1987).

Ortmann (1918) collected mussels as far upstream as Big Stone Gap (PRM 178.2), but subsequent surveys reported sites above PRM 140 to be heavily impacted by coal and silt deposition, and no mussels were found above PRM 165 (Ahlstedt & Brown, 1979; Neves et al., 1980; Dennis, 1981; Ahlstedt, 1986). Ahlstedt (1986) listed 36 mussel species in the Powell River, including 15 species endemic to the Cumberland Plateau Region. Seven endangered species (federal list) reside in the Powell River: dromedary pearlymussel (*Dromus dromas*), shiny pigtoe (*Fusconaia cor*), fine-rayed pigtoe (*F. cuneolus*), cracking pearlymussel (*Hemistena lata*), birdwing pearlymussel (*Lemiox rimosus*), Cumberland monkeyface (*Quadrula intermedia*), and Appalachian monkeyface (*Q. sparsa*).

Jenkinson & Ahlstedt (1988) documented a decline in overall mean abundance of freshwater mussels at selected sites in the Powell River over the past decade: 7.25 mussels/m^2 in 1979, 4.87 mussels/m^2 in 1983, and 2.41 mussels/m^2 in 1988. They found that many species declined significantly between 1979 and 1983, perhaps reflecting the mussel die-off that occurred in 1983 (Ahlstedt & Jenkinson, 1987). Because of discrepancies in reports of mussel diversity from previous surveys and the suspected but undocumented declines in recruitment within populations, we conducted a mussel survey to reassess the diversity, range, and relative abundance of species in the Powell River, Lee County, Virginia.

MATERIALS AND METHODS

Study Area

The Powell River flows southwesterly from near Norton, Virginia, through the Ridge and Valley Province of the Appalachian Mountains into Tennessee, where it joins the Clinch River in Norris Reservoir. Study sites in the Powell River, Virginia, were selected according to suitability of habitat for mussels, similarity among sites (such as riffles, runs, and type of substratum), and accessibility (Figure 1). Most sites were selected from a list of locations previously surveyed so that comparisons could be made (Ahlstedt & Brown, 1979; Neves et al., 1980; Dennis, 1981; Ahlstedt, 1986; Jenkinson & Ahlstedt, 1988).

Qualitative Sampling

Qualitative sampling was conducted to assess distribution and relative abundance of uncommon mussel species not likely to be collected in quadrat samples. Fifteen sites were surveyed using a combination of waterscopes, snorkeling, and wading (Table 1). Surveying times ranged from 0.5 to 3 h, depending on the amount of suitable habitat at each site. All mussels observed during

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[2]The Virginia Cooperative Fish and Wildlife Research Unit is jointly sponsored by the National Biological Survey, Virginia Department of Game and Inland Fisheries, Wildlife Management Institute, and Virginia Polytechnic Institute & State University.

this time were collected, identified, measured, and replaced. Numbers of the state-protected spiny riversnail (*Io fluvialis*) also were recorded.

Quantitative Sampling

Quantitative surveys were conducted at nine of the 15 sites on the Powell River, identified by Powell River Mile: 117.3, 120.4, 123.0, 128.4, 144.6, 146.8, 153.4, 163.4, and 165.7 (Table 1). One 0.5-m^2 quadrat was taken for every 100 m^2 of suitable mussel habitat, which included optimal and marginal areas. A minimum of 10 quadrats and a maximum of 20 quadrats were taken at each site. Quadrat samples were obtained using a 0.5-m^2 metal frame, and samples were allocated among riffles and runs according to area. Quadrat points were located randomly. The substratum was searched to about 15 cm in depth with the aid of a mask and snorkel. All live mussels contained in the 0.5-m^2 area were removed, identified, and measured for length (maximum anterior to posterior distance). Mussels were replaced near their original location in the siphoning position. Numbers were converted to densities per square meter at each site. Densities of the exotic Asian clam (*Corbicula fluminea* [Müller]) and the protected spiny riversnail also were recorded to determine the abundance of these species. Common and scientific names of mollusks follow Turgeon et al. (1988); authors of the scientific names are given in Table 2.

Mean densities among sites were compared by Kruskal-Wallis tests. Differences in mean lengths of the pheasantshell (*Actinonaias pectorosa*) were compared among sites and with previously collected data using ANOVA procedures.

RESULTS

Species Composition and Distribution

Quantitative and qualitative mussel sampling in 1988 and 1989 yielded 28 mussel species, including nine endangered species (five on federal list and four on state list; Table 2). The Tennessee pigtoe (*Fusconaia barnesiana*) and Tennessee clubshell (*Pleurobema oviforme*) are difficult to distinguish solely from external characteristics; therefore, these specimens were grouped together as one taxon. Endangered mussel species were found at several sites (Table 3), but not above Poteet Ford (PRM 144.6). The spiny riversnail also was found at most sites but was absent above PRM 163.4. No live mussels or relic shells were found above PRM 167.4. The sites with highest diversity on the Powell River in Virginia were located farthest downstream, and there was an obvious increase in the number of species of mussels from upstream to downstream (Figure 1).

Two of the most diverse sites in the downstream portion of the river are at Fletcher Ford (PRM 117.3) and Snodgrass Ford (PRM 123.0). Sampling at Fletcher Ford recorded 19 mussel species. Snodgrass Ford, not previously documented as a mussel bed, supported a diverse and abundant fauna of 22 mussel species.

Mussel Densities in Quadrat Samples

Mussel densities declined progressively upstream, and mussels were very rare above PRM 163.4 (Table 4). Mussel abundances were too low upstream of PRM 163.4 to be quantified by quadrat sampling; however, mussels were collected by qualitative sampling. Comparison of mussel densities by Kruskal-Wallis analysis showed significant differences among sites (P=.0001), and multiple comparisons were made using Wilcoxon two-sample tests

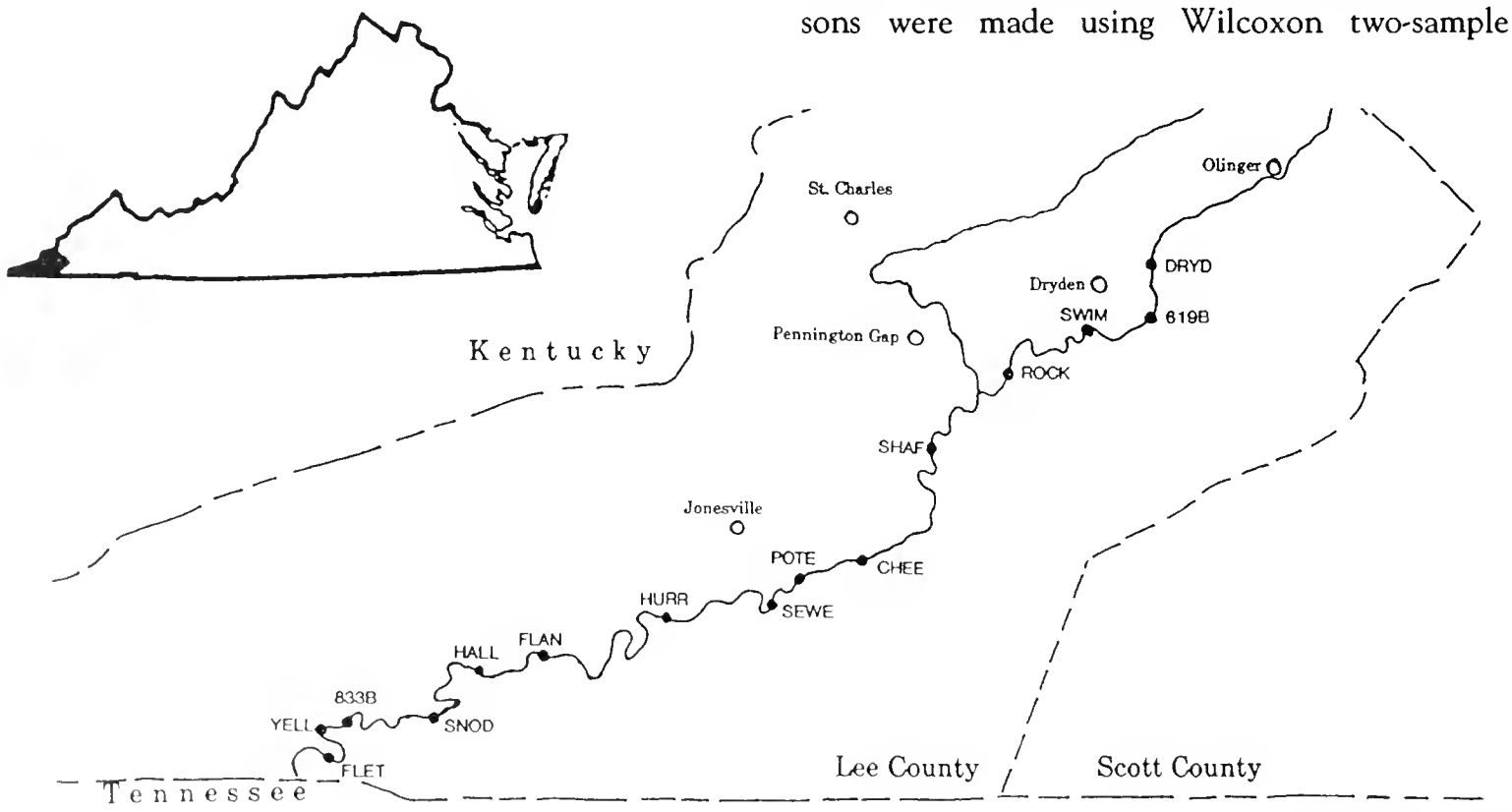

Figure 1. Sample sites on the Powell River, Lee County, Virginia.

Table 1. Sites sampled for mussels in the Powell River, Virginia, 1988-89.

Site (abbreviation)	River Mile	Location
Fletcher Ford (FLET)	117.3	Rte. 678 off Rte. 661; private access, locked gate.
Yellow Creek (YELL)	119.3	Rte. 661, above swinging bridge; downstream of Yellow Creek confluence.
Rte. 833 Bridge (833B)	120.4	Rte. 833 bridge off Rte. 661.
Snodgrass Ford (SNOD)	123.0	Rte. 667 off Rte. 679; approx. 0.5 mile downstream of swinging bridge.
Hall Ford (HALL)	128.4	Gravel road off Rte. 662; under swinging bridge.
Flanary Bridge (FLAN)	130.6	Downstream of Rte. 758 bridge.
Hurricane Bridge (HURR)	138.3	Downstream of Rte. 654 bridge.
Sewell Bridge (SEWE)	143.5	Rte. 70 bridge.
Poteet Ford (POTE)	144.6	Gravel road off Rte. 783; downstream of swinging bridge.
Cheekspring Ford (CHEE)	146.8	Rte. 783; under swinging bridge.
Shafer Ford (SHAF)	153.4	Rte. 640; side of island.
Rock Island (ROCK)	158.3	Gravel road off Rte. 642.
Swimming Hole (SWIM)	163.4	Gravel road off Rte. 642; downstream of swinging bridge.
Rte. 619 Bridge (619B)	165.5	Downstream of Rte. 619 bridge.
Dryden (DRYD)	167.4	Gravel road at Rte. 58 bridge; at island upstream of bridge.

(Table 5). Snodgrass Ford had a significantly higher mussel density (24/m^2) than all other sites. Densities of mussels at Fletcher Ford and the Route 833 bridge were not significantly different from each other but were greater than at all other sites. Densities of the spiny riversnail were significantly different among sites ($P=.0001$), with the highest numbers occurring at Snodgrass Ford and Fletcher Ford (Table 5). Densities of Asian clams also were significantly different among sites ($P=.0001$), with the highest numbers occurring at Hall Ford, Snodgrass Ford, Fletcher Ford, and at the Route 833 bridge (Table 5).

Qualitative Samples

The number of mussel species collected was greater in qualitative surveys than quantitative surveys (Table 6). Generally, most of the common species were collected in quadrat samples, while rarer species were found during qualitative sampling. The highest number of species was collected at Fletcher Ford. The pheasantshell (*A. pectorosa*) and mucket (*A. ligamentina*) were the most common mussel species at sampled sites. The number of mussels and species collected per unit of effort declined progressively upstream, except at some midstream sites (Table 6). Results of collection per unit effort data concur with quadrat samples on longitudinal trends in abundance; namely, mussel abundance decreased in an upstream direction.

Size Class Differences Among Sites

Lengths of mussels were used to represent age

structure of populations at sample sites. Mean lengths of *A. pectorosa* were compared by ANOVA among three sites with sufficient sample sizes, and there were significant differences (P=0.0001) among locations (Table 7). The mean length (86.7 mm) of *A. pectorosa* was lowest at the Route 833 bridge, indicating better recruitment and mid-age adults at this site. Snodgrass Ford had the highest mean length (106.9 mm), which implies reduced recruitment. Size class distributions of *A. pectorosa* show similar trends (Table 8); however, the lack of young mussels is evident at all sites. Although a large sample (n=139) of *A. pectorosa* was collected at Snodgrass Ford, no individuals less than 60 mm in length were observed. Age estimates from length data indicate that few individuals are less than 7 years old, suggesting low recruitment over the last decade.

Shell lengths of *A. pectorosa* collected at Fletcher Ford during quadrat surveys in 1988 were compared with those taken in 1978 (Neves et al., 1980). A t-test indicated no significant difference in average lengths of *A. pectorosa* between the 2 years (P=0.5388). A comparison of median length classes between these years, however, indicated an obvious decline in the number of smaller mussels at this site. The collection of only one specimen in the first seven median size classes in 1988 implies poor recruitment over the last decade (Table 9).

Table 2. Mussel species collected in the Powell River, Virginia, 1988 and 1989.

Scientific name	Common name
Actinonaias ligamentina (Lamarck)	mucket
Actinonaias pectorosa (Conrad)	pheasantshell
Amblema plicata plicata (Conrad)	three-ridge
Cyclonaias tuberculata (Rafinesque)	purple wartyback
Dromus dromas (Lea)[1]	dromedary pearlymussel
Elliptio dilatata (Rafinesque)	spike
Epioblasma brevidens (Lea)[2]	cumberlandian combshell
Epioblasma capsaeformis (Lea)[2]	oyster mussel
Epioblasma triquetra (Rafinesque)[2]	snuffbox
Fusconaia barnesiana (Lea)	Tennessee pigtoe
Fusconaia cor (Conrad)[1]	shiny pigtoe
Fusconaia subrotunda (Lea)	long-solid
Lampsilis fasciola (Rafinesque)	wavy-rayed lampmussel
Lampsilis ovata (Say)	pocketbook
Lasmigona costata (Rafinesque)	fluted-shell
Lemiox rimosus (Rafinesque)	birdwing pearlymussel
Ligumia recta (Lamarck)[2]	black sandshell
Medionidus conradicus (Lea)	Cumberland moccasinshell
Plethobasus cyphyus (Rafinesque)[2]	sheepnose
Pleurobema oviforme (Conrad)	Tennessee clubshell
Potamilus alatus (Rafinesque)	pink heelsplitter
Ptychobranchus fasciolaris (Rafinesque)	kidneyshell
Ptychobranchus subtentum (Say)	fluted kidneyshell
Quadrula cylindrica strigillata (Wright)	rough rabbitsfoot
Quadrula intermedia (Conrad)[1]	Cumberland monkeyface
Quadrula sparsa (Lea)[1]	Appalachian monkeyface
Villosa iris (Lea)	rainbow
Villosa vanuxemensis vanuxemensis (Lea)	mountain creekshell

[1]Federal endangered species
[2] State endangered species

Table 3. Locations of mussel species collected in the Powell River, Virginia, 1988 and 1989.

Species Site	FLET	YELL	833B	SNOD	HALL	FLAN	HURR	SEWE	POTE	CHEE	SHAF	ROCK	SWIM	619B	DRYD
River mile	117.3	119.3	120.4	123.0	128.4	130.6	138.3	143.5	144.6	146.8	153.4	158.3	163.4	165.5	167.4
Actinonaias ligamentina	X	X	X	X	X	X	X	X	X	X	X	.	.	.	.
Actinonaias pectorosa	X	X	X	X	X	X	X	X	X	X	X	X	X	.	X
Amblema plicata plicata	.	.	X	X	X	X	.	X	X	.	.	.	.	.	.
Cyclonaias tuberculata	X	X	X	X	X	.	.	X	X	.	.	.	.	.	.
Dromus dromas	X	X	X	X	.	.	.	.	.	.	.	.	.	.	.
Elliptio dilatata	X	X	X	X	X	.	.	X	X	X	X	X	.	X	.
Epioblasma brevidens	X	.	X	X	X	.	.	X	.	.	.	.	.	.	.
Epioblasma capsaeformis	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.
Epioblasma triquetra	X	.	.	X	X	X	.	.	.	.	.	.	.	.	.
Fusconaia/Pleurobema	X	.	X	X	X	.	.	.	X	X	.	.	.	.	.
Fusconaia cor	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.
Fusconaia subrotunda	X	X	X	X	X	X	X	X	X	X	X	X	.	.	X
Lampsilis fasciola	X	X	X	X	X	.	X	X	X	X	X	X	X	.	X
Lampsilis ovata	.	X	X	X	.	X	X	X	X	.	X	.	.	.	.
Lasmigona costata	X	.	X	X	X	X	X	X	X	X	X	.	.	.	.
Lemiox rimosus	X	.	.	.	.	.	.	.	X	.	.	.	.	.	.
Ligumia recta	X	.	X	X	.	.	.	.	.	X	.	.	.	.	.
Medionidus conradicus	X	X	X	X	X	.	.	X	.	.	.	.	.	X	.
Plethobasus cyphyus	X	.	.	X	.	.	.	.	.	.	.	.	.	.	.
Potamilus alatus	X	.	.	X	.	X	X	X	X	X	X	.	.	.	.
Ptychobranchus fasciolaris	X	X	X	X	.	.	.	X	X	X	X	X	.	.	X
Ptychobranchus subtentum	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.
Quadrula cylindrica strigillata	.	.	X	.	.	X	.	X	X	.	X	X	.	.	.
Quadrula intermedia	X	X	X	X	X	.	.	X	X	.	.	.	.	.	.
Quadrula sparsa	X	X	.	.	.	.	.	.	X	.	.	.	.	.	.
Villosa iris	.	.	.	X	X	.	.	.	.	.	.	.	.	.	X
Villosa v. vanuxemensis	.	.	.	.	.	.	.	.	.	X	X	X	X	X	.
Total species	19	12	18	22	14	9	7	15	16	11	11	7	3	3	5
Federal endangered spp.	4	3	2	3	1	.	.	1	3	.	.	.	.	.	.
State endangered spp.	3	.	2	3	2	1	.	1	.	.	.	.	.	.	.

DISCUSSION

Species Composition and Distribution

Species composition and distributional differences are apparent when survey results from this study are compared with survey data of the last 15 years (Ahlstedt & Brown, 1979; Neves et al., 1980; Dennis, 1981; Ahlstedt, 1986; Jenkinson & Ahlstedt, 1988). More mussel species were found at sites upstream of Flanary Bridge (PRM 130.6) than was reported by earlier surveys (Table 10). Because unusually low and clear water conditions in 1989 facilitated sampling, discrepancies among studies in species densities and richness at upstream sites are presumably due to ineffective sampling in previous surveys and not to recovery of mussel populations. Generally, species diversity has decreased at lower sites (below PRM 130.6) since earlier surveys. Loss of species richness is probably due to extirpations of some species at lower sites and is not an artifact of sampling method or effort.

Declines in mussel diversity and distribution in the Powell River are obvious when compared with mussel surveys of the early 1900s (Ortmann, 1918). Particularly noticeable is the current absence of mussels upstream of

Table 4. Number of mollusks per square meter in quadrat samples from the Powell River, 1988.

Species:	Site:	FLET	833B	SNOD	HALL	POTE	CHEE	SHAF	SWIM	619B
	River mile:	117.3	120.4	123.0	128.4	144.6	146.8	153.4	163.4	165.7
Mussels										
Actinonaias ligamentina		0.7	0.5	5.0	0.2	-	-	-	-	-
Actinonaias pectorosa		3.7	3.0	13.9	0.6	0.1	0.8	0.2	-	-
Cyclonaias tuberculata		0.1	-	-	-	-	-	-	-	-
Dromus dromas[1]		-	-	0.1	-	-	-	-	-	-
Elliptio dilatata		0.4	0.6	2.2	-	0.1	-	-	-	-
Epioblasma brevidens[2]		0.3	0.1	-	-	-	-	-	-	-
Fusconaia subrotunda		0.6	0.3	1.0	-	0.5	-	-	-	-
Lampsilis fasciola		0.1	-	-	-	-	-	0.2	-	-
Lampsilis ovata		-	-	0.1	-	-	-	-	-	-
Lemiox rimosus[1]		-	-	-	-	0.1	-	-	-	-
Ligumia recta[2]		-	-	0.1	-	-	-	-	-	-
Medionidus conradicus		0.5	0.6	1.4	-	-	-	-	-	-
Plethobasus cyphyus[2]		0.1	-	-	-	-	-	-	-	-
Quadrula intermedia[1]		-	-	0.2	-	-	-	-	-	-
Villosa v. vanuxemensis		-	-	-	-	-	-	-	0.2	-
Mean density (No./m^2)		6.5	5.1	24.0	0.8	0.8	0.8	0.4	0.2	-
Other Mollusks										
Corbicula fluminea		201.2	134.2	267.7	266.8	43.8	71.4	100.0	71.4	46.4
Io fluvialis		3.1	2.0	5.0	1.6	0.9	-	0.2	-	-
No. of Quadrats		20	20	20	10	20	10	10	10	10

[1]Federal endangered species
[2]State-endangered species

Table 5. Comparison of mean densities of mollusks among sites along the Powell River, as determined by quadrat sampling in 1988.

Mussels			Spiny Riversnail			Asian Clam		
Site	Mean	SE	Site	Mean	SE	Site	Mean	SE
SNOD	24.0a[1]	1.63	SNOD	5.0a	0.35	HALL	266.8a	19.14
FLET	6.5b	0.50	FLET	3.1ab	0.42	SNOD	267.7a	23.38
833B	5.1b	0.54	833B	2.0bc	0.33	FLET	201.2ab	22.13
HALL	0.8c	0.22	HALL	1.6bc	0.25	833B	134.2bc	13.26
CHEE	0.8c	0.22	POTE	0.9bc	0.17	SHAF	100.0bc	10.39
POTE	0.8c	0.18	SHAF	0.2cd	0.10	CHEE	71.4cd	10.39
SHAF	0.4c	0.13	CHEE	0.0d	0.00	SWIM	71.4cd	7.53
SWIM	0.2c	0.10	619B	0.0d	0.00	619B	46.4d	4.15
619B	0.0c	0.00	SWIM	0.0d	0.00	POTE	43.4d	3.92

[1]Means with the same letter are not significantly different ($p \geq 0.05$) according to Wilcoxon 2-sample tests.

Dryden (PRM 167.4). Ortmann (1918) collected mussels at least up to PRM 177.8 at Big Stone Gap. Mussels have not been collected upstream of PRM 167.4, at least as far back as 1973 (Dennis, 1981). Unfortunately, no records are available before that time to determine when mussels declined or disappeared from the upstream reaches of the Powell River, although effects from mining and industrialization have been ongoing for the last 50 years (Dennis, 1981). Mussels are thought to have been eliminated from the Big Stone Gap area because of acid mine drainage that occurred prior to environmental regulations (Wollitz, 1985).

At least nine mussel species have been extirpated from the Powell River, Virginia, since Ortmann's (1918) report: elktoe (*Alasmidonta marginata* [Say]), slippershell mussel (*A. viridis* [Rafinesque]), elephant-ear (*Elliptio crassidens* [Lamarck]), acornshell (*Epioblasma haysiana* [Lea]), Tennessee heelsplitter (*Lasmigona holstonia* [Lea]), little-wing pearlymussel (*Pegias fabula* [Lea]), squawfoot (*Strophitus undulatus* [Say]), purple lilliput (*Toxolasma lividus* [Rafinesque]), and purple bean (*Villosa perpurpurea* [Lea]). Several of these species were headwater forms and probably were affected by upstream pollution; others were present only downstream and were eliminated by Norris Dam and the impoundment of the Clinch and Powell rivers (Ahlstedt & Brown, 1979; Dennis, 1981). Several species may have extended their range upstream in the last 70 years. The mucket (*A. ligamentina*) is common at most sampled sites in Virginia, but was not collected by Ortmann (1918) above the Tennessee border. Similarly, some species reported in recent surveys were not documented by Ortmann (1918) in the Powell River, Tennessee or Virginia, although most of them are rare and probably were missed in his early surveys. However, the purple wartyback (*C. tuberculata*) is now fairly common and may be a recent invader (Ahlstedt & Brown, 1979).

Sharp declines in mussel densities in the Powell River are obvious when compared with previous collection records. During 1978, Neves et al. (1980) provided a mean density estimate of 24.2 mussels/m^2 at Fletcher Ford. Quadrat surveys by Jenkinson & Ahlstedt (1988) at Fletcher Ford estimated densities of 11.1 mussels/m^2 in 1979, 10.3 mussels/m^2 in 1983, and 5.5 mussels/m^2 in 1988. Our survey estimated an abundance of 6.5 mussels/ m^2 in 1988. While densities often vary among similar sites in a river, periodic sampling of the same site should provide a precise estimate of mussel abundance (Dennis, 1984). As judged by these density estimates, a substantial decline in mussel abundance has occurred at this site, probably due to lack of recruitment and mortality of adult mussels.

The distribution of the spiny riversnail also has declined. Historically, *Io fluvialis* was collected above Olinger, Virginia (PRM 172.0), by Adams (1915). The spiny riversnail was collected up to PRM 163.4 in our survey; however, densities decreased markedly upstream of PRM 128.4. In 1979, spiny riversnails were collected up to PRM 156.8, with maximum densities of 5.7/m^2 (Tennessee Valley Authority, 1979). The highest density of 5.0/m^2 in our survey was recorded at Snodgrass Ford (PRM 123.0). As judged by survey results, the upstream range of *Io fluvialis* has decreased roughly 15.5 km since 1915.

Length Frequency Distributions

Unfortunately, few historical data on length frequencies are available to compare changes in mussel sizes

or age class structure over time. Only Neves et al. (1980) recorded mussel lengths during their survey. Statistical analyses and size class structure confirm that the number of smaller (younger) mussels has decreased in the last 10 years at Fletcher Ford. The 1980 quadrat survey indicates that younger mussels can be sampled by quantitiative sampling methods. However, the absence of individuals in six of the smallest length classes in 1988 indicates that the lack of recruitment has been a long-term event and is not related solely to variable recruitment among years. Length frequency histograms of common species such as *A. ligamentina, F. subrotunda*, and *E. dilatata* confirmed the lack of young age classes for all species. Recruitment of young mussels at this site is not occurring, and mussel populations are in decline for as yet unknown reasons.

Length frequency distributions also were used to identify poor recruitment at other sites. Mean lengths of *A. pectorosa*, the most abundant mussel in the Powell River, were smallest at the Route 833 bridge. This site was the only place where smaller (juvenile) mussels were collected. At Snodgrass Ford, no evidence of recruitment was found, and old-age individuals made up the entire assemblage. Mussel densities at Snodgrass Ford were similar to those recorded at Fletcher Ford in 1978 (Neves et al., 1980). Snodgrass Ford should be monitored periodically to determine whether reproduction and recruitment are occurring at this diverse site. The presence of endangered species such as the dromedary (*D. dromas*) and Appalachian monkeyface (*Q. sparsa*) at this location warrants further evaluation.

Mussel Declines

Because mussels are long-lived animals, effects of environmental change may not be evident for many years. Improvements in water quality occurred in the Powell River when discharges came under federal and state regulation; however, the mussel fauna may still be suffering from the effects of degradation that occurred many years ago.

Our conclusion from length frequency analyses and survey results is that, at present, almost no recruitment of

Table 6. Collection of mollusks per unit of sampling effort in the Powell River, 1988.

Site	River Mile	Number of mussels	Number of species	Mussels /hour	Number of spiny riversnails	Snails /hour
FLET	117.3	333	16	111.0	124	41.3
YELL	119.3	220	11	73.3	13	4.3
833B	120.4	103	15	34.3	27	13.5
SNOD	123.0	554	14	184.7	156	52.0
HALL	128.4	92	9	30.7	23	7.7
FLAN	130.6	24	9	12	6	3.0
HURR	138.3	63	7	25.2	0	0
SEWE	143.5	143	15	47.7	6	2.0
POTE	144.6	148	14	49.3	27	10.8
CHEE	146.8	75	10	25.0	4	1.3
SHAF	153.3	11	4	4.4	2	1.0
ROCK	158.3	20	7	6.7	25	8.3
SWIM	163.4	2	1	1.6	1	0.8
619B	165.5	3	3	2.0	0	0
DRYD	167.4	0	0	0	0	0

Table 7. Differences in mean lengths of pheasantshells (*Actinonaias pectorosa*) among sites, as determined by ANOVA of quadrat and qualitative surveys, 1988.

Quadrat Surveys		Qualitative Surveys	
833B	86.7a[1]	833B	101.8a
FLET	100.1b	YELL	104.6ab
SNOD	106.9c	POTE	107.8bc
		FLET	109.7c
		HALL	109.7c
		SNOD	114.4d
		CHEE	114.0d
		SEWE	116.8d
		HURR	119.3d

[1]Means with the same letter are not significantly different ($p \geq 0.05$) according to Fisher's protected least-significant-difference procedure (LSD).

mussels is occurring at most sampled sites in the Powell River. Possible reasons for this lack of recruitment include impaired or lack of reproduction, mortality of juveniles, loss of host fishes, or a combination of these factors. A comparison of data from fish surveys in 1988 (Alan Temple, unpublished data) with those of Tennessee Valley Authority (1970), Masnik (1974), and Neves et al. (1980) showed no major reductions or changes in fish species over time. Therefore, the diversity and availability of host fish species probably has not declined significantly in the Powell River. However, the absolute and relative abundances of these fish species over time has not been determined.

Mussel declines in Atlantic drainage rivers have been attributed to the development of dense populations of the Asian clam (Clarke, 1988). This exotic species first appeared in the Powell River in 1979 (Ahlstedt, 1986) and was considered common by 1983. It is now widespread in the river and may be competing for food and space with juvenile native mussels. Research is needed to investigate the potentially negative interactions between these bivalve taxa.

Contaminants

Water quality in the Powell River generally exceeds standards established by the Virginia Water Control Board (1985). However, there are only two ambient water quality stations on the Powell River, and samples are taken only monthly at best. More frequent or high flow sampling would be more appropriate because many types of pollution are episodic events, occurring during storms or incidents of permit violations. Pollution from agriculture, logging, domestic sewage, coal mining and other industries has increased since Ortmann (1918) collected mollusks in the Powell River. Although several sources of pollution exist, perturbations originating from coal mining, and abandoned mine lands are potential point and non-point source problems affecting the upper Powell River drainage.

Conservation and protection of the diverse mussel fauna in the Powell River will depend on the identification and correction of environmental problems detrimental to mollusk survival and reproduction. Cooperative monitoring and research by state regulatory agencies and

Table 8. Median size class distribution and estimated age of pheasantshells, as determined by quadrat and qualitative surveys, 1988.

	Median size class (mm) (Estimate of age)														
SITE	5 (1)	15 (2)	25 (3)	35 (4)	45 (5)	55 (6)	65 (7)	75 (8)	85 (9-10)	95 (11-12)	105	115	125	135	145
Quantitative samples															
FLET	-	-	1	-	-	-	-	3	7	5	7	10	3	1	-
833B	2	1	-	-	-	-	-	3	5	11	6	2	-	-	-
SNOD	-	-	-	-	-	-	1	5	10	27	37	42	20	2	-
HALL	-	-	1	-	-	-	-	-	-	-	3	-	-	-	-
CHEE	-	-	-	-	-	-	-	-	-	-	1	2	1	-	-
SHAF	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
Qualitative samples															
FLET	-	-	-	-	-	-	-	1	17	25	39	80	30	4	1
YELL	-	-	-	-	-	-	2	1	13	22	40	44	3	-	-
833B	-	-	-	-	-	-	-	1	8	6	15	9	2	-	-
SNOD	-	-	-	-	-	-	-	2	1	17	40	84	58	4	2
HALL	-	-	-	-	-	-	-	-	1	7	5	13	12	-	-
FLAN	-	-	-	-	-	-	-	-	-	1	1	3	1	-	-
HURR	-	-	-	-	-	-	-	-	-	-	-	7	3	2	-
SEWE	-	-	-	-	-	-	-	-	-	2	10	15	11	4	-
POTE	-	-	-	-	-	-	-	-	-	2	23	15	1	-	-
CHEE	-	-	-	-	-	-	-	-	1	1	9	19	9	1	-
SHAF	-	-	-	-	-	-	-	-	-	1	1	1	-	-	-
ROCK	-	-	-	-	-	-	-	-	-	-	3	1	-	-	-

federal agencies such as the Office of Surface Mining, Environmental Protection Agency, and U.S. Fish and Wildlife Service is essential to achieve recovery of mussels in the Powell River watershed.

SUMMARY

A survey of the freshwater mussel fauna of the Powell River, Virginia, was conducted in 1988 and 1989 to assess diversity and population trends during the last half century. Mussels were collected as far upstream as Powell River Mile (PRM) 167.4 near Dryden, Virginia. Endangered species were collected up to PRM 144.6 at Jonesville, Virginia. Sites with the greatest mussel diversity were downstream, and there was an obvious decline in abundance and diversity progressing upstream. The highest density occurred at Snodgrass Ford (PRM 123.0), with 24 mussels/m^2. Live mussels were rare above Pennington Gap (PRM 158.3), whereas historic records of mussels were as far upstream as Bigstone Gap (PRM 178.2). A decline in density of mussels in the Powell River has occurred in the past 25 years. Statistical comparisons of quadrat data and length frequency distributions of the pheasantshell (*Actinonaias pectorosa*) indicate an absence of smaller mussels at most sites. There is little if any recruitment of young mussels to declining populations. Effluents and siltation from coal mining, abandoned mine lands, and wastewater treatment plants are suspected of contributing to the decline of mussels.

Table 9. Median size class distribution of pheasantshells, as determined by quadrat surveys at Fletcher Ford in 1978 and 1988.

	Median size class (mm)														
Year	5	15	25	35	45	55	65	75	85	95	105	115	125	135	145
1978	-	2	4	1	5	3	-	7	8	12	16	17	17	6	1
1988	-	-	1	-	-	-	-	3	7	5	7	10	3	1	-

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Table 10. Species diversity reported in mussel surveys conducted at selected sites in the Powell River, Virginia.

Site (PRM)	Survey*						
	A	B	C	D	E	F	G
FLET (117.3)	28	12	17	27	15	10	19
YELL (117.9) -	-	26	10	0	-	3	
833B (120.4)	24	21	18	11	-	-	18
SNOD (123.0) -	-	-	-	-	-	22	
HALL (128.5) -	-	5	18	-	-	14	
FLAN (130.6) 4	8	13	-	6	5	9	
HURR (138.3) -	1	6	-	-	-	7	
SEWE (143.5) -	-	2	-	-	-	15	
POTE (144.6)	9	12	5	-	-	-	16
CHEE (146.8) 0	-	-	-	-	-	11	
TRAS (153.4) -	-	2	-	-	-	11	
ROCK (158.3) -	-	0	-	-	-	7	
SWIM (163.4) -	-	1	-	-	-	3	
619B (165.7)	2	1	-	-	-	-	3
DRYD (167.4) 1	1	4	-	-	-	5	

*A = 1973-1978 (Dennis 1981)
B = 1975-1978 (Ahlstedt and Brown 1979)
C = 1979 (Ahlstedt 1986)
E = 1983 (Jenkinson and Ahlstedt 1988)
F = 1988 (Jenkinson and Ahlstedt 1988)
G = 1988-1989 (present study)

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Additions and Emendations to the Virginia Fauna of "True Bugs" (Heteroptera: Cydnidae, Scutelleridae, Pentatomidae, Alydidae)

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In two fascicles of "The Insects of Virginia" published some years ago, I provided brief accounts of the pentatomoid (No. 4, 1971) and coreoid bugs (No. 9, 1975) belonging to seven families of the Heteroptera. Since the appearance of those references, substantial collections of these insects have been made throughout the state by myself as well as other individuals, including staff members of various state agencies (in particular, the Virginia Agricultural Extension Service (VPI&SU) and the Division of Natural Heritage, Department of Conservation and Natural Resources), resulting in the addition of several species to the state list. A considerable number of name changes have also occurred during the past two decades, so that a general update of the two fascicles seems desirable.

No. 4: Scutelleroidea

Many new distributional records for pentatomoids were published (Allen & Hoffman, 1975, 1976) in two rather informal journals of the U. S. Department of Agriculture (Cooperative Economic Insect Report, 1975, and Cooperative Plant Pest Report, 1976).

Larivière (1992) has recently proposed the new genus *Parabrochymena* for a number of mostly tropical species, including that treated in 1971 as *Brochymena arborea*. The correct name for this insect is now *Parabrochymena arborea*.

The late R. I. Sailer (in litt., 1972) and numerous authors (e.g., McDonald 1975) established that the generic name *Peribalus*, under which I included the single species *P. limbolarius*, should be replaced by *Holcostethus*. Dr. Sailer also advised that the specific name *Chlorochroa uhleri* should be corrected to *C. persimilis* Horvath.

The pentatomid listed by me (1971) as *Rhytidolomia belfragei* Stal was later (Thomas, 1983) described as a new species, *Chlorochroa dismalia*. This species remains known only from the holotype and a second specimen, also from the Dismal Swamp, in the Louisiana State University collection.

A revision of the pentatomid subfamily Asopinae by Thomas (1992) introduced several name changes for Virginia species. The genus *Apateticus* was divided into two, with the name *Apoecilus* revived for several species including our *A. cynicus* (Say). Thomas also pointed out that the name *modesta* Dallas, 1851, was a junior synonym of *Podisus maculiventris* (Say) and not applicable to the species to which previously applied; the latter was given the new name *Podisus brevispinus*. Lastly, he showed that the species hitherto known as *P. fretus* Olsen should correctly be called *P. neglectus* (Westwood).

During this time, one addition was made to the state's fauna of scutelleroids, with the description of what I (1971: 15) discussed as a color variant of *Corimelaena lateralis* (Fabricius) as a new species, *C. obscurus*, by McPherson & Sailer in 1978. Several others may now be accounted.

Scutelleridae

Diolcus chrysorrhoeus (Fabricius). In 1971 I stated "Recorded by Brimley (1938: 60) from Cape Hatteras, N. C., and thus very likely to be discovered in extreme southeastern Virginia." Among material obtained by VMNH from the University of Richmond insect collection are four specimens of this species from Cape Hatteras, North Carolina, and one labeled "Chesterfield Co./M. Williams/11-XII-1937". Perhaps this record should be held in abeyance pending confirmation by the discovery of additional specimen. Chesterfield County is somewhat more inland than one would expect from the otherwise sublittoral northern range of the species, which, furthermore, has not been found elsewhere in southeastern Virginia despite intensive collection in the Virginia Beach area. Also, M. Williams collected one of the Cape Hatteras specimens (which his pin label attributed to "S.C."). Dr. A. G. Wheeler suggests the additional possibility that the specimen may have been taken in Chesterfield Co., South Carolina, which is within the recorded range of the species.

Disjunct distributions are extremely frequent with insects, especially in poorly-collected regions, and populations may be extremely localized. This record deserves provisional acceptance until checked thoroughly along the tidal reaches of the James and Appomattox rivers.

A specimen of *D. chrysorrhoeus* in the VPISU collection requires less attention. From a general entomology collection, it was ostensibly collected at Blacksburg in October 1978. The natural occurrence of this coastal species in western Virginia is totally implausible, and the species is one not likely to be accidentally transported in goods or plant material.

Cydnidae

Microporus obliquus Uhler. Heretofore the presence of this species in Virginia was known only from a collection made at Cape Henry, in Virginia Beach City (Froeschner, 1960). It is possible to add a second locality, albeit quite near the first: Dam Neck Naval Base, where one specimen was trapped at the "dune drift fence site", cleared 7 September 1990, during the Natural Heritage Program survey.

Melanaethus cavicollis (Blatchley). This burrowing bug was included as a probable in my 1971 treatment because of its known occurrence in eastern North Carolina (Blatchley, 1924). The survey of Seashore State Park, Virginia Beach City, which was conducted by the Natural Heritage Program in 1989-1990, yielded a single specimen from the "dune site" pitfall array, cleared on 26 July 1989. That the pitfalls were operated year-round for 15 months and produced but a single specimen suggests virtually no surface movement by the species, in contrast to the one that follows.

Tominotus communis (Uhler). Brimley (1938) listed this species for North Carolina without specific locality. Since the locality nearest Virginia cited by Froeschner (1960: 553) was Allardt, Roane Co., Tennessee, I postulated (1971: 24) that *T. communis* might be looked for in the vicinity of Bristol. While that possibility is still a viable one, the species turned up first in Virginia Beach, during the Heritage Program's sampling in Seashore State Park. Pitfall arrays were operated in three habitats, referred to as the "dune", "scrub", and "mesic" sites, but of the 27 specimens of *T. communis* taken during 1989, not one was trapped in the "mesic" site. Their occurrence at the other two sites is noteworthy. Specimens were taken during the sampling periods ending on May 1 to November 1, as summarized in the following table:

Date	Dune site	Scrub site
1 May		6
19 May	1	6
7 June	1	
21 June	2	
5 July	2	
26 July	4	
18 August		2
29 September	2	
1 November		1

It is curious that considerable surface activity commenced at the scrub site from mid-April to mid-May, and then essentially shifted during the summer to the dune site. Trapping during the first four months of 1990 did not produce any *communis* at either site, perhaps the influence of a late spring. Is the scrub site possibly better for hibernation, and dune better for the active life? Lastly, the species was not taken in pitfalls operated during the same time period at six other nearby sites in Virginia Beach. It is apparently ultra-stenotopic.

Froeschner's North Carolina material was from Southern Pines only, so that Seashore State Park is a range extension of 220 miles (355 km) to the northeast.

Aethus nigritus (Fabricius). The occurrence of this common Palearctic cydnid in northeastern United States has been treated comprehensively by Hoebeke & Wheeler (1984). These authors mapped the then-available records, discussed biology and habitat, and provided a historical summary of the species' establishment in this country, which dates back only to 1977.

VMNH possesses a series of 18 adults of *A. nigritus* taken from pitfalls set at the Dam Neck Navy Base, City of Virginia Beach, Virginia. The collection dates suggest a summer-long period of activity: 6 June 1990 (3), 1 August 1990 (1), 7 September 1990 (1), 12 October 1990 (2), 14 May 1991 (3). and 28 May 1991 (8). Since a number of Dam Neck samples have not yet been sorted, it is possible that many additional individuals remain to be recovered. Facies of the habitat sampled ("dune drift fence site") coincide with the preferred biotopes mentioned by Hoebeke & Wheeler. It is interesting to note that *nigritus* has not appeared in pitfall samples taken at a dozen other sites in Virginia Beach, several of them also in "dune" environments. Perhaps we have here a case of a recently introduced population still establishing its beachhead.

Previous known records are from Delaware, Pennsylvania, New Jersey, and Connecticut. The Virginia Beach population extends the species' range some 300 km (180 miles) south from Townsend, Delaware.

In my key to the Virginia genera of Cydninae (1971: 21), *Aethus* will identify as *Microporus* in couplet 4, but is readily distinguished by the virtually glabrous dorsum and much more extensive evaporatorial surface. The presence of both short stout "pegs" and macrosetae along the edges of the head give the impression of a small form of *Tominotus communis* (with material of which the VMNH specimens were at first intermixed).

Pentatomidae (Acanthosomatidae)

Elasmostethus atricornis (Van Duzee). Information published prior to 1971 identified this species as native to northeastern United States as far south as Maryland, and since its host plant (*Aralia spinosa* L.) is common in Virginia, I predicted the bug would eventually be found in this state. This prophesy was fulfilled on 8 August 1991, when I found specimens (VMNH) on the flowers of *A. spinosa* along Va. Rt. 702 in Breaks Interstate Park, Dickenson Co., Virginia. In life their dorsal color was a fine light greenish-yellow with brown posterior pronotum, quite distinct from the more sombre hues of *E. cruciatus*.

This is by no means the southernmost locality for *E. atricornis*, however, as it had already been recorded from the western, mountainous part of Oconee Co., South Carolina, by Jones & McPherson (1980).

Following Blatchley (1926), I treated the acanthosomatine pentatomids as a subfamily of Pentatomidae. More recently a concensus has favored its elevation to full family status.

No. 9: Coreoidea

No nomenclatorial changes have affected the Virginia species of Coreidae, Alydidae, and Rhopalidae, except that in 1980, the subgeneric name *Boisea* was raised (Göllner-Scheiding, 1980) to generic rank to include, among others, the species that I treated in 1975 as *Leptocoris trivittatus*. This modification has not met with the complete approval of other specialists on rhopalids (e.g. Schaefer & Chopra, 1982), and until the relationships of the genera *Leptocoris* and *Jadera* have been worked out perhaps it is best to continue use of *Leptocoris* for the Virginia species.

One species of Coreidae, *Acanthocephala declivis* (Say) was added to the fauna of Virginia by me in 1992 (Banisteria 1: 19), from a specimen taken along the James River in Surry County.

Coreidae

The tenuous evidence for inclusion of the cactus bug, *Chelinidea vittiger*, in the Virginia fauna was reviewed in my 1975 account. After nearly two decades of intensive (and invariably negative) inspections of *Opuntia* colonies, many of them very extensive, in many parts of the state, I am now forced to the belief that former optomism was misfounded. The imprecise early record for "Virginia" cited by Uhler (1863) could have been based upon a specimen taken in the lower Kanawha River valley prior to the separation of West Virginia. The single nymph supposedly taken at Herndon in 1911 has never been substantiated despite decades of collecting in northern Virginia. The specimen must have been mislabeled or misidentified.

It is herewith proposed that C. *vittiger* be removed from the list of Virginia coreids.

Alydidae

Stenocoris tipuloides (DeGeer). On 9 September 1993 an adult male thought to be of this species (see comment below) was collected by John M. Anderson of the VMNH staff near our pitfall site 1.2 miles (2 km) east of Claresville, Greensville Co., Virginia. We had recovered the trap contents and were making general collections in the vicinity prior to departure at nightfall. The *Stenocoris* was taken by sweeping tall grasses and sedges along a ditch bordering a long-fallow field, and in the net its form and green color persuaded me that it was a nymphal *Zelus luridus*. This misapprehension was dispelled when the specimen was pinned and recognized as an alydid. Subsequent reference to the collection at the National Museum of Natural History, and with extensive aid from Dr. R. C. Froeschner, led to provisional adoption of DeGeer's name. However, inconsistencies in the treatment of this genus in the most recent revision (Ahmad, 1965) and comparison of USNM material compels the opinion that when the Neotropical fauna of *Stenocoris* has been carefully studied, *tipuloides* may be applied to a species quite different from that at hand.

Although this "tipuloides" is common in Florida and southern Georgia, there are no records for North Carolina in Brimley's 1938 list, nor material in the USNM collection. The northernmost localities known to me are represented by two specimens from South Carolina in the Clemson University collection, one from Blackville, Bamberg County (5 August 1938), the other from Clemson, Oconee Co. (14 July 1936). Of these locations, Blackville is in the Coastal Plain where the species would be expected to occur. Clemson is substantially more inland, and the specimen cited may be adventitious or mislabeled. With reference to Blackville, the Claresville specimen extends the known range of

tipuloides about 450 km (270 mi) northeastward.

The genus was not even considered as probable for Virginia when I compiled my 1975 treatment and was not included in the key to local genera of Alydidae, in which *Stenocoris* will identify as *Protenor* in the first couplet. The two may be easily distinguished by examination of the beak: in *Stenocoris* the third and fourth segments are subequal in length; in *Protenor* the fourth is at least twice as long as the third.

Summary

The following name changes have affected Virginia heteropterans since publication of my two synopses (1971, 1975):

Brochymena arborea becomes *Parabrochymena arborea*
Peribalus limbolarius becomes *Holcostethus limbolarius*
Podisus modestus becomes *Podisus brevispinus*
Podisus fretus becomes *Podisus neglectus*
Apateticus cynicus becomes *Apoecilus cynicus*
Chlorochroa uhleri becomes *Chlorochroa persimilis*
Rhytidolomia belfragei becomes *Chlorochroa dismalia*

The following species are added to the 1971 and 1975 lists:

Diolcus chrysorrhoeus (Fabricius) (Scutelleridae)
Corimelaena obscurus McPherson & Sailer (Corimelaenidae)
Tominotus communis (Uhler) (Cydnidae)
Aethus nigritus (Fabricius) (Cydnidae)
Melanaethus cavicollis (Blatchley) (Cydnidae)
Elasmostethus atricornis (Van Duzee) (Pentatomidae)
Stenocoris tipuloides (DeGeer) (Alydidae)

The following species should be deleted from the Virginia list:

Chelinidea vittiger Uhler (Coreidae)

Phenetic and biotope information on *Tominotus communis* in Seashore State Park suggests an interesting problem to be investigated in depth.

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Gasteracantha cancriformis (L.), a Spectacular Spider New to the Fauna of Virginia (Araneae: Araneidae)

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Knowledge of the spider fauna of Virginia has increased significantly in recent years, primarily as a result of pitfall surveys conducted by the Virginia Museum of Natural History and the Division of Natural Heritage (DNH), Virginia Department of Conservation and Recreation. These surveys have resulted in numerous new state records of terrestrial species (Hoffman, 1992; Hoffman, unpublished). However, pitfall trapping rarely results in captures of orb-weaving spiders (Araneidae).

Gasteracantha cancriformis (Linnaeus) is one of the most spectacular spiders in North America. Females of this orb-weaving species are easily recognized by their wide, sclerotized abdomens, which are adorned with six prominent spines, as illustrated in Levi (1978) and several popular works (e.g., Levi & Levi, 1990; Milne & Milne, 1980). Males are much smaller than females and lack abdominal spines (Levi, 1978). The previously reported range of G. *cancriformis* within the United States extended from North Carolina south to Florida and west to California (Kaston, 1978; Levi, 1978). This species also inhabits the West Indies and ranges south from Mexico to northern Argentina (Levi, 1978).

During the course of faunal surveys conducted by DNH staff in southeastern Virginia during the past several years, records of G. *cancriformis* were obtained at the following three sites (from south to north): **City of Virginia Beach:** False Cape State Park, one female, 3 July 1991, K. A. Buhlmann. **Surry Co.:** Swanns Point, Colonial National Historical Park, 3 km NNW of Scotland, one female, 5 October 1993, S. M. Roble. **Northampton Co.:** Greens Creek at County Route 600, 3 km NE Nassawadox, five females, 3 December 1993, S. M. Roble. These records extend the known range of G. *cancriformis* approximately 280 km N of the nearest North Carolina locality plotted in Levi (1978).

No data are available on the abundance of G. *cancriformis* at False Cape State Park. However, it is common at both of the other sites. Adult females were found in webs 1.5-2.5 m above ground level on trees and shrubs. Adult males were not actively sought at any of the three sites. The Swanns Point site is across the James River from Jamestown Island (James City County). A brief survey of the island on the same date failed to reveal the presence of G. *cancriformis*. The Greens Creek site is nearly 50 km N of the tip of the Delmarva Peninsula and also within 5 km of the Accomack County line. Due to the absence of any obvious biogeographic barrier in this area, it is likely that G. *cancriformis* ranges further north on the Eastern Shore of Virginia toward Maryland.

Acknowledgements

I thank Chuck Rafkind and Herman Barber of Colonial National Historical Park and Barry Truitt of The Nature Conservancy (Virginia Coast Reserve) for arranging access to the collection sites in Surry and Northampton Counties, respectively. All specimens are deposited in the collection of the Virginia Museum of Natural History, Martinsville. I thank Richard L. Hoffman for making me aware of the specimen from False Cape State Park.

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Timber Rattlesnakes (*Crotalus horridus*) in Prince William Forest Park: Released Captives or Native Population?

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The timber rattlesnake (*Crotalus horridus*) apparently occurred throughout much of Virginia from the Chesapeake Bay to the mountains before the arrival of Europeans in the early 1600s (Tobey, 1985; Mitchell, in press). Subsequently, the colonists and their descendants cleared much of the landscape of its forest and eliminated many populations of animals (Silver, 1990; Martin & Boyce, 1993), resulting in the elimination of numerous populations of timber rattlesnakes in the Commonwealth. The exceptions were those in mountainous regions, mountain ridges in the Piedmont, and in the uplands and swamps in the southeastern corner of the state (Mitchell, in press). The discovery of two specimens of timber rattlesnakes in Prince William Forest Park, Prince William County, Virginia, in 1991 (Martin et al., 1992) revealed, however, that all of the Piedmont populations may not have become extinct.

The uniqueness of the Prince William Forest Park specimens lies in the fact that they are the only ones known from the lower Piedmont physiographic province. The closest known extant population is in the Bull Run Mountains, some 40 km to the northwest (Martin et al., 1992). Some aspects of the biology of mountain populations are reasonably well-known (Martin, 1992, 1993) but little is known of lowland populations.

This paper contains a review of the history of the discovery of timber rattlesnakes in Prince William Forest Park, an analysis of the phenotypic characteristics of the specimens, and an assessment of the question of whether the specimens were released captives or natural occurrences.

Methodology

The primary method of obtaining information on areas occupied by rattlesnakes was to conduct walk-through transects in likely habitat and conduct nighttime searches on park roads (Scenic Drive) in summer. Areas searched include the southwestern and southern portions of Prince William Forest Park (PWFP), especially along the South Branch of Quantico Creek. Previous sightings and locations of road-killed specimens served to focus field efforts. All appropriate cover objects were examined for snakes, such as logs and rocks, stumps, and other places that may be used as hiding places. Rocky outcroppings were located on maps and evaluated for potential hibernating sites. William H. Martin III accompanied me on one occasion in the fall of 1993 to assess potential den sites and to evaluate the available information on the snakes found in 1991.

Meristic and morphometric data were obtained from PWFP specimens and those from Bull Run Mountains and Shenandoah National Park for comparison. Snout-vent length (SVL) and tail length was measured on preserved specimens with a tape measure to the nearest mm. Number of ventral scales was counted using the Dowling method (Dowling, 1951), where the first ventral is the one connecting the first dorsal scale row on each side. Numbers of subcaudals, dorsal scale rows, and dorsal body blotches were counted using standard techniques (Peters, 1964).

Historical Review

Timber rattlesnakes were not known from Prince William Forest Park until July 1991, despite the fact that the area became federal property in 1936 and has been used extensively for human recreation since that time. The park is composed of approximately 6,920 hectares of former farmland that was allowed to succeed naturally to the mature hardwood forest typical of northern Virginia. The area was farmed extensively for corn, cotton, and tobacco from the early 1700s to about 1930 and then largely abandoned. The lands were purchased as part of a Depression-era program set up as an example of proper stewardship, to encourage the return to natural conditions by preventing soil erosion and stream pollution, and to facilitate reforestation (U.S. Dept. of Interior, 1992).

Until recently, *Crotalus horridus* has not been considered a part of the snake fauna of Prince William County. The locality in northwestern Prince William County plotted in Linzey & Clifford (1981) has been sustantiated recently by W. H. Martin III (pers. comm.) who has observed a specimen on the eastern side of the Bull Run Mountains. Another observation for the county is unverifiable. A note in an unpublished report (Anonymous, date unknown) indicated that a dead timber rattlesnake (size not indicated) had been found in a red-tailed hawk (*Buteo jamaicensis*) nest on Quantico Marine Corps Base sometime during 1971-1975. A parent hawk could have either picked up the snake many kilometers away from its nest, possibly in the Bull Run Mountains, and brought it to the area, or the snake could have been found locally.

The first specimen of C. *horridus* known from Prince William Forest Park was found by G. T. Davis on 13 July 1991 at milepost 7.3 on Scenic Drive (the interior park road). The snake was a 950 mm SVL (1005 mm total length, preserved measurements) gravid female that was kept in captivity until October. Between 20 and 22 August 1991 she gave birth to 9 live neonates and one stillborn (litter size = 10). The live neonates were released in mixed hardwoods south of Scenic Drive and near the location of the female's initial capture on 11 October 1991. None have been recaptured.

The female was also released in the vicinity of her original capture (south of the road in a section of mixed hardwoods) on 11 October 1991. She was subsequently found run over by a car south of the original capture location on Scenic Drive on 19 October 1991. This female and her stillborn neonate were donated to the National Museum of Natural History (USNM 314211 and 314212, respectively).

During the time the female adult was in captivity, a 270 mm SVL (290 mm total length) juvenile C. *horridus* was found dead on Scenic Drive by Marie Frias on 15 September 1991 (USNM 314213).

Other rattlesnake sightings have been reported in Prince William Forest Park and on Quantico Marine Base. An unconfirmed sighting of an "Eastern Diamondback" rattlesnake was reported by K. Thompson on 31 July 1991 from a location east of the High Meadows trail, in the same vicinity in which the first two specimens were located. He noted that it was about 1.3 m long and was crossing Scenic Drive. If this sighting is reliable and the identification was of a timber and not a diamondback rattlesnake, then at least one additional adult was alive in PWFP in late 1991.

A live male timber rattlesnake was found on Engineer Road in the Officer Candidate School area on Quantico Marine Corps Base in early October 1990 (Dolan, 1990). This snake had been injured prior to capture. Its skin had been torn away from the muscle on the lower right jaw. It otherwise appeared healthy. This snake was assumed to have been a released captive; its original capture location is unknown.

To date, no other specimens or reasonably accurate sightings of timber rattlesnakes have been reported in Prince William Forest Park or on Quantico Marine Corps Base.

Phenotypic Characteristics

Meristic and morphometric characteristics of the snakes reported above are compared to samples from the Bull Run Mountains in Fauquier County, the northern section of Shenandoah National Park, and the statewide Virginia sample in Table 1. Scale counts, relationship of tail length to total length, and numbers of dorsal markings on the specimens from Prince William Forest Park and Quantico Marine Corps Base do not differ from the values characteristic of the closest natural populations located farther west in Virginia or from the statewide samples. The number of dorsal scale rows align the two PWFP specimens with southeastern Virginia samples, but they are not the lowland subspecies, *Crotalus horridus atricaudatus*, that is listed as state endangered (Mitchell & Schwab, 1991). The two PWFP specimens do not have the characteristic chestnut middorsal stripe or eye-jaw stripe. Scale counts and tail length/total length values suggest that the juvenile specimen (USNM 314212) is a female.

Unfortunately, these comparisons do not allow us to ascertain whether the snakes were originally captured in Prince William Forest Park (or nearby Quantico) or from another location in their known natural range.

Released Captives or Native Population?

The limited number of sightings in Prince William Forest Park (2) make it difficult to determine the true origin of the snakes. Three lines of evidence were pursued to obtain information that led to a reasonable conclusion: (1) searches for additional specimens and potential den sites, (2) evaluation of the behaviors and physical conditions of the specimens to determine if they were of captive origin, and (3) information on the behavior of the snakes and possible release of captives, and the history of the park.

Road cruising at night and daytime searches for additional specimens yielded no new information. Several potential den sites along the south fork of Quantico Creek near the intersection with the High Meadows Trail were examined in August and September 1993. On 24

October 1993, William H. Martin III accompanied me to several of these sites and confirmed that those on the south-facing bank of the South Fork of Quantico Creek could be potential overwintering sites for one to several snakes. However, there was no external evidence that they were currently being used by any snake. Another difficulty was that it was not possible from external examination to determine whether there were any fissures that would allow snakes to hibernate below the frost line. Thus, the information based on field searches was inconsequential.

I examined the specimens in the National Museum of Natural History for evidence of captive conditions (e.g., rubbed noses, scale wear, parasites). None were apparent on either of the two specimens from PWFP. Lack of evidence does not mean, however, that the snakes were not former captives.

The suggestion that the two snakes were former captives comes from two sources: an unexpected telephone call and the behaviors of the snakes. In early 1992 I received a call from a captive snake breeder in northern Virginia. He indicated that he knew the person who had released these and other snakes in PWFP. This person had apparently been releasing snakes in the park for a number of years. I could not obtain the person's name from him.

As noted by William H. Martin, mid-October is the time that low elevation timber rattlesnakes move from summer foraging areas to winter hibernacula. Adults and juveniles are usually moving towards den sites. Movement of timber rattlesnakes in PWFP should have been towards the rock outcrops along the South Fork of Quantico Creek, assuming these are the only den sites in the area. We do not know the orientation of the two snakes on Scenic Drive when they were killed. However, the fact that the adult female was released over 100 meters south of the road and that she was subsequently found on the road, suggests that she was disoriented. An adult with experience in finding her overwintering site in an area with which she was familiar should have oriented towards the rock outcrops and not back toward Scenic Drive.

Additionally, PWFP receives 200,000–500,000 visitors annually; the latter figure when park day use was free. The cabins have been in continual use since the 1940s with campers who frequently hike all the park's trails. Thus, the probability that naturally occurring timber rattlesnakes could have existed in PWFP since its establishment and gone unnoticed is very low.

Conclusions

The conclusion I draw from the admittedly scanty evidence discussed above is that timber rattlesnakes are not native residents of Prince William Forest Park, although they could have been prior to European settlement. The two and possibly three specimens discovered in 1991 were apparent releases by a well-meaning snake enthusiast who assumed that the snakes would survive in the park's forested habitat.

Releasing snakes that have been held in captivity into areas with which they are unfamiliar may reduce their survivorship, not enhance it, as believed by their well-intended, but uninformed human captors. Such released snakes, like other animals that learn the physical features in their native home ranges, are at a disadvantage compared to native snakes. Non-native individuals will rove over the unfamiliar landscape at high risk to themselves. Such individuals are not likely to survive for long.

Acknowledgments

I thank Riley Hoggard of PWFP for inviting me to participate in this research and providing funding. Marie Frias in PWFP Resource Management was particularly helpful in all aspects of this project. Specimens from Bull Run Mountains and Shenandoah National Park were examined through the kindness of G. R. Zug and R. W. McDiarmid (National Museum of Natural History) and the park rangers who picked up road-killed snakes on Skyline Drive in the 1980s for me. I am especially grateful to William H. Martin III for spending a day with me in the park and sharing his wealth of knowledge on timber rattlesnakes. Carl H. Ernst and William H. Martin III graciously reviewed the manuscript.

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A Novel Habitat for Larvae of the Fishfly *Chauliodes pectinicornis* (Megaloptera: Corydalidae)

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The fishfly *Chauliodes pectinicornis* (Linnaeus) is widely distributed, having been reported from 26 eastern states as well as Quebec (Dolin & Tarter, 1981). The larvae, commonly called hellgrammites, are strong, active predators (Neunzig & Baker, 1991) restricted to lentic habitats with little water movement (Cuyler, 1958). Larvae have been recorded most commonly from woodland pools and shaded swamps, but occasional records from open ponds and pools exist (Neunzig & Baker, 1991). That the larvae are well adapted to such oxygen-poor habitats as woodland pools is attested by the fact that they possess a pair of long, contractile, caudal respiratory tubes which enable them to reach the air/water interface for gas exchange. The present paper reports the collection of this species from a water-filled treehole, a habitat not unlike a woodland pond. It is the first published record for a megalopteran from this habitat.

As part of an ongoing study of the acarine inhabitants of water-filled treeholes, I collected water, leaves, and debris as well as the associated fauna from a treehole near Williamsburg, Virginia, in early July of 1990. The sample was placed in a finger bowl, covered with a petri dish lid to impede evaporation, and used as a source of mites for experimentation. While examining the sample in September, I noted a respiratory tube extending to the air-water interface from beneath a piece of submerged bark. On closer examination I found the tube belonged to a fishfly larva approximately 35 mm in length (Fig. 1). With the use of keys to larval Megaloptera (Chandler, 1956; Cuyler, 1958) it was identified as *Chauliodes pectinicornis*.

The larvae of a number of insect species are common and often obligate inhabitants of water-filled treeholes in eastern North America, including those of several species of flies (Psychodidae, Syrphidae, Ceratopogonidae, Culicidae) and beetles (Scirtidae) (Fashing, 1975). A thorough examination of the culture dish revealed mites to be the only arthropods remaining with the fishfly larva, their small size allowing them to escape predation. It is presumed that insect larvae present at the time of collection had been consumed. Fishfly larvae are fiercely predacious, eating almost anything they can subdue (Chandler, 1956). Scirtid larvae were therefore collected from water-filled treeholes and used as a food source for the fishfly larva. The specimen remained concealed in the debris consuming scirtid larvae until 29 March 1991, when it was observed moving about on top of the debris. On 1 April it metamorphosed to a pupa which remained partially submerged with its head and prothorax above the water line until it eclosed to an adult on 11 April. If the pupa was removed from its submerged position and placed atop the debris, it would move back into the water. In nature, *Chauliodes* larvae construct pupal cells under the bark of soft and moist rotting logs lying in the water or along the water's edge, with cell construction being above the water level if the log is in the water (Neunzig & Baker, 1991). Although the observation of more individuals is necessary for corroboration, it appears that if soft, moist logs are not available, the preferred pupation site is the water rather than debris above the water line.

Although several authors have hypothesized the life cycle for the genus *Chauliodes* to vary between two and three years (Neunzig & Baker, 1991), a study by Dolin & Tarter (1981) revealed a univoltine cycle based on head widths from monthly field collections. It is therefore likely that my individual was collected as an egg or first instar larva, and grew rapidly until it was large enough to be noticed. Dolin & Tarter (1981) report that larvae of *C. pectinicornis* show the greatest growth in the field from July to October and from April to June, with adults emerging from field collected pupae in late June and throughout July. The early adult emergence (11 April) of my individual is explained by the fact that larval growth was not interrupted by the cold and lack of food experienced by field individuals during the winter months.

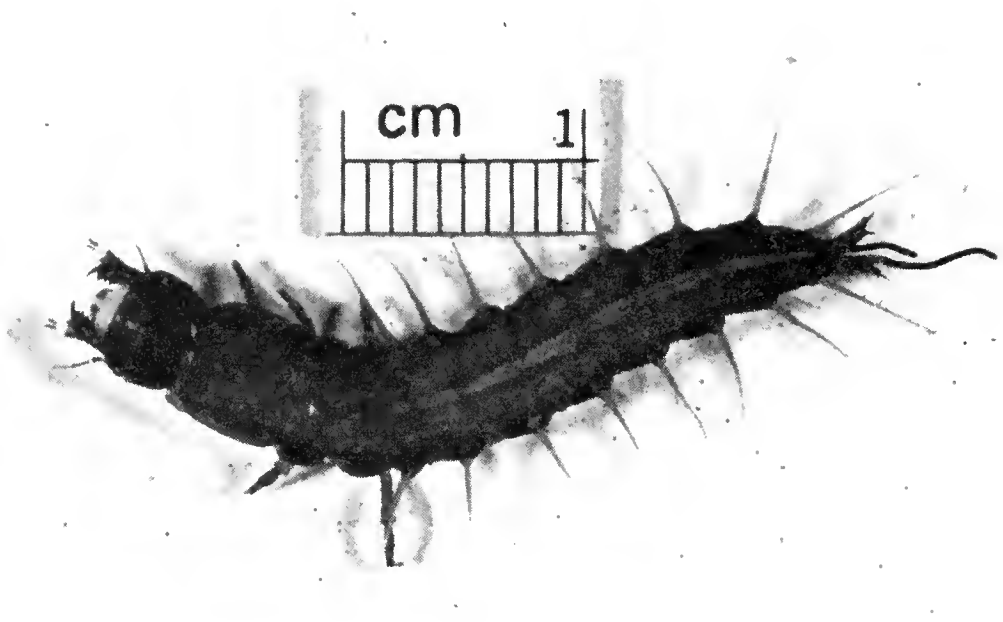

Figure 1. Larva of *Chauliodes pectinicornis* collected from a water-filled treehole.

That a C. *pectinicornis* larva was found in a water-filled treehole is not at all surprising when one considers the species' usual habitat. It is often found in small woodland pools where there are layers of debris and decaying organic matter. The water-filled treehole is in fact such a pond, albeit small. In locations where there is sufficient precipitation throughout the year, treeholes can attain a relatively permanent status (i.e., contain standing water most of the year) (Fashing, 1975). Such treeholes provide a unique habitat for a relatively large number of species, many of which are obligate inhabitants (Lacky, 1940; Snow, 1949; Rohnert, 1950; Fashing, 1975; Kitching, 1971; Kitching & Callaghan, 1982). It should be pointed out that some of these obligate inhabitants have life cycles of one year or longer. A number of other species have been recorded as occasional residents of water-filled treeholes, and *Chauliodes pectinicornis* can now be counted among them.

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Rediscovery of the Dragonfly *Nannothemis bella* Uhler in Virginia (Odonata: Libellulidae)

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A total of 181 species of Odonata has been recorded from Virginia, including 130 dragonflies and 51 damselflies (Carle 1982, 1988; Division of Natural Heritage (DNH) database). One additional dragonfly, *Gomphus septima* Westfall, has been reported from the state solely on the basis of sight records (Carle, 1991). Carle's (1991) figure of 193 confirmed species (132 + 61) appears to be in error as it presumably includes numerous damselflies of hypothetical status. Differences in the dragonfly totals can be attributed to our recognition of two species included in his tally as subspecies.

In his comprehensive summary of Virginia's dragonfly fauna, Carle (1982) provided detailed collection records for every species confirmed from the state. No similar compilation exists for the damselfly fauna of Virginia, although Carle has prepared a species list (Carle, 1988) and provided DNH with selected museum and personal collection records for several of the rarer species. Based on this information and recent field surveys by DNH, we have determined that only six of the 181 species (3.3%) have not been collected in Virginia during the past quarter-century. These elusive species and their last year of collection in Virginia are: *Celithemis ornata* Rambur (1938), *Enallagma pallidum* Root (1938), *Ischnura prognata* Hagen (1938), *Libellula quadrimaculata* Linné (collection date unknown but prior to 1938), *Nannothemis bella* Uhler (1890) and *Neurocordulia virginiensis* Davis (1919). These records indicate that *N. bella* has been the most elusive species of Odonata in Virginia, where it had not been seen in more than a century prior to the 1993 field season.

Nannothemis bella is the smallest dragonfly in North America (and one of the smallest in the world), attaining a maximum length of 21.5 mm (Walker & Corbet, 1975). Females of this species are easily recognized by their small size and black and yellow striped abdomens (see color photo in Milne & Milne, 1980). Males become powdery blue when mature, superficially resembling males of *Erythrodiplax connata minuscula* Rambur (see color photo in Dunkle, 1989), except for their significantly smaller size and more blackish abdomens. The reported range of *N. bella* extends from Maine and Quebec south to Florida and west to Wisconsin and Louisiana (Needham & Westfall, 1955; Shiffer, 1985; Walker & Corbet, 1975). The species is more common in the northern part of its range, becoming very local southward (e.g., Shiffer, 1985; White et al., 1980). The preferred habitat is bogs and boggy ponds (Carpenter, 1991; Shiffer, 1985; Walker & Corbet, 1975). The reported flight season is from mid-April to early September (Needham & Westfall, 1955).

Prior to 1993, the only Virginia record of *N. bella* was based on two adult males collected by C. W. Johnson on 19 June 1890 along the Great Wicomoco River in Northumberland County (Carle, 1982). The species is apparently absent from the Buck Run Ponds at Locust Fork Recreation Area, George Washington National Forest in Highland County, the site of many interesting dragonfly records reported by Carle (1982). This diminutive dragonfly has not been found at any of the numerous sinkhole ponds in the Shenandoah Valley (Augusta and Rockingham Counties) as well as those surveyed in Isle of Wight County and the City of Newport News.

As a result of extensive odonate surveys conducted by DNH staff as part of a rare species inventory of the Fort A. P. Hill Military Reservation in Caroline County, we are able to report two new records of *N. bella* as follows: Beaver pond immediately E of Lonesome Gulch Pond, 5.2 km NNE junction state routes 2 and 207 in Bowling Green, one female, 17 June 1993, P. H. Stevenson; Bettys Bottom Pond, 7 km ESE junction state routes 2 and 207 in Bowling Green, three males, one

[1]Present address of PHS: 5300 W. Franklin Street, Richmond, VA 23226

female, 28 July 1993, S. M. Roble. The former site is in the northern half of the base and the latter site is in the southern half of the base. The two are separated by a linear distance of 8.7 km.

Although several dozen other ponds were surveyed on Fort A. P. Hill (as well as two very acidic ponds elsewhere in the county), *N. bella* was found only at the two sites listed above. These are two of the three most exemplary boggy ponds identified on the base by DNH plant ecologists (G. P. Fleming, personal communication). Despite several visits to the Lonesome Gulch site during the flight season of *N. bella*, the only adult observed there was the single female collected on 17 June. Only one brief visit to Bettys Bottom Pond was possible during the flight season of *N. bella* because of active military training activities. Approximately 20 adults were observed in a boggy cove near the southeastern corner of the pond. Several additional adults were noted further north along the pond's margin on the same date by J. C. Ludwig (pers. comm.).

We have not yet attempted to relocate the site of the original record of *N. bella* in Northumberland County. However, following the documentation of this species at Fort A. P. Hill, the first author surveyed three recently discovered fen-like seepage habitats on the Virginia portion of the Delmarva Peninsula. These sites (all in Accomack County) are ecologically unique and very significant botanically (Ludwig & Rawinski, 1993) but small in size (largest site ≤1 acre) and contain limited areas of open water. Similar habitats in Delaware support newly discovered populations of *N. bella* as well as numerous rare plants (J. C. Ludwig, pers. comm.). The Virginia sites were visited on 24 and 25 August 1993 (*N. bella* was still active in Delaware several days later *fide* J. C. Ludwig), but no adults were observed, and it appears that this species does not inhabit these sites. However, the seepage-loving damselfly *Argia bipunctulata* (Hagen), another very local species (Dunkle, 1990), was found at two of the three sites. One of these populations (>200 adults observed) is the largest currently known in Virginia.

Acknowledgements

Field surveys at Fort A. P. Hill were funded by a contract between the U.S. Department of Defense and the Virginia Department of Conservation and Recreation. SMR thanks J. Christopher Ludwig for information on *N. bella* and for directing him to the Accomack County sites. All specimens are currently deposited in the reference collection of the Division of Natural Heritage.

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Banisteria, Number 3, 1994

Male Combat in Copperheads (*Agkistrodon contortrix*) from Northern Virginia

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Male combat in snakes refers to ritualized behavioral interactions between males, usually during the mating season (Carpenter & Ferguson, 1977). The behavior has been recorded in numerous species of boiids, colubrids, elapids, and viperids worldwide (Carpenter, 1986). The objective of the behavior is to determine which of the snakes is the dominant male, with the winner of the combat usually mating with a nearby female. Such domineering behavior is correlated with sexual size dimorphism; if males are the larger sex, then large size is advantageous during behavioral competition with other males (Shine, 1978). Schuett & Gillingham (1989) found in laboratory experiments that larger male copperheads were successful in defending mates during courtship and that larger males were winners in 11 of 13 trials involving male-male interactions.

Observations of male combat in northern copperheads (*Agkistrodon contortrix mokasen*) in nature are rare. J. Ackroyd (in Gloyd, 1947) witnessed male combat in this species in late June 1945 in Frederick County, Virginia (his observations are repeated in Mitchell, in press). Mitchell (1981) reported a putative instance of male combat based on the discovery of two large males in the City of Richmond on 3 August 1980 that had been entwined when killed by a resident. In this note, we report a confirmed instance of male combat in *A. contortrix* in Virginia and explore the timing of this behavior.

At 1330 hr EDT on 23 August 1992 the senior author discovered two large (1-1.3 m) northern copperheads on a hill above Carter Run in a heavily forested property near County Route 691, ca. 10 km NW of Warrenton, Fauquier County, Virginia. The snakes were behind a woodshed on a low pile of metal roofing, old fence posts, and various pieces of lumber. The large males were entwined and lying outstretched on top of one of the pieces of metal roofing. The snakes struggled together for 5–10 minutes, each attempting to achieve the superior, as well as anterior, position. As the snakes moved forward and upward, they would occasionally slide backward on the metal; the roofing was slightly inclined toward the rear of the snakes. SHS moved to within 3 meters to photograph the snakes, who became alarmed and then disentangled. One snake took cover under the piece of metal roofing and the other made its way to a nearby pushed-over stump and disappeared down a hole at its base.

A close inspection of the immediate vicinity revealed a third, smaller copperhead (about 2.5 ft) coiled on top of an old, leaf litter-covered piece of plywood 2-3 meters from the main pile of materials. This snake was probably a female.

In his eleven-year study of copperheads in Kansas, Fitch (1960) concluded that male combat occurred only rarely or at night, and even then the snakes were secretive. Ackroyd's observations (in Gloyd, 1947) took place at 2230 h. Thus, the observation reported above demonstrates that this behavior may occur in Virginia copperheads during the day, as well as at night.

Our observation of male combat in August helps confirm that this behavior and at least some mating events take place in Virginia *Agkistrodon contortrix* in late summer. W. H. Martin III (pers. comm.) observed male combat in Albemarle County on 5 September 1976, providing further substantiation. Wood (1954) thought that male combat in this species "takes place in spring." The laboratory-based observations on mating and male combat made by Schuett & Gillingham (1989) occurred in two periods, February-April and August-October. The accumulated field observations of mating in copperheads fall in two periods, April-May and September-October (Ernst, 1992). Mating has been observed in Virginia in April and May (Mitchell, in press) and in September (W. H. Martin, III, pers. comm.). It follows that male combat behavior in copperheads should occur during the spring mating period, as well as in the late-summer to fall mating period, as observed above. Obviously, observations of male combat in spring are needed to confirm its occurrence in both of these seasons in Virginia.

Acknowledgments

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Sampling Soil Arthropods at Mountain Lake Biological Station, Virginia, Over a 32-Year Period[1]

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For the past 32 years, the first laboratory-field exercise in my basic entomology course (Biology of Insects) has involved collecting a small soil sample and extracting from it the animals (micro-fauna) that can be retrieved by use of a Berlese funnel. This course has been offered 16 times, essentially in alternate summers, at Mountain Lake Biological Station of the University of Virginia, 1.6 km north of Mountain Lake, in Giles County, Virginia. Each time but the first, in 1961, the results of our census of recovered animals were recorded and retained, a copy having been given to each member of the class.

Each sample was one square foot of soil one inch deep (approximately 30.5 x 30.5 x 2.5 cm., or 2326 cc.), together with any covering leaf-litter. Samples were biased in some ways: we avoided large tree roots and sought places where low herbaceous plants would be minimally damaged; we also avoided sampling beneath coniferous trees because of the effects of resins on soil fauna. Some ecological factors, such as soil temperature at one-inch depth compared to air temperature, were in each case recorded. (The average difference, over the years, was 4.5°C, with the actual soil temperatures varying according to the season and the weather of the year, from 12.8 to 18.9°C, with a mean of 17.1°C.)

All samples were taken within 80 meters of the main laboratory building at the Station and were from the shallow, sandy, friable soil overlying the gray sandstone characteristic of much of the top of Salt Pond Mountain on which the lake and the biological station are located. The soil has a high humus content and in most areas contains a tangle of roots and rootlets. Typical second-growth forest shading the sample sites includes oaks (chiefly *Quercus alba* and *Q. rubra*), maples (*Acer rubrum, A. pennsylvanicum*), yellow birch (*Betula alleghaniensis*) and black gum (*Nyssa sylvatica*); conifers are sparse in the immediate area. Understory plants include saplings of these and of chestnut (*Castanea dentata*), as well as ericaceous shrubs (*Vaccinium, Gaylussacia*, and others). Ground-cover plants include ferns of several species, fly poison (*Amianthium muscaetoxicum*), dewberry (*Rubus villosus*), and a variety of others. Dates of sampling were between 11 and 16 June, when the course was taught in the first summer term, and 16 and 24 July when in the second term.

Over the years, two groups of arthropods, the Acarina (mites) and the Collembola (springtails), have dominated the census figures, as can be seen in Table 1 by comparing total sample counts with the totals for these groups. Although Collembola outnumbered Acarina in two-thirds of the samples, the Acarina show the greater numbers overall. Furthermore, the Acarina have consistently exhibited the greater diversity, always being represented by many different families.

Such non-hexapod taxa as Symphyla, centipedes, millipedes, pseudoscorpions, and micryphantid spiders have routinely been found. Of these, only the Symphyla were often present in considerable numbers (24 to 195 individuals; see Table 1), while the others were recovered in low numbers. Larval Coleoptera and Diptera (particularly Nematocera) were common, and immatures of Homoptera, Thysanoptera, Psocoptera, Lepidoptera and Mecoptera appeared from time to time. Samples usually contained a few ants and occasionally adult insects representing other orders. Small numbers of non-arthropod organisms were found in most samples; these included annelids (earthworms), nematodes (probably many of the extremely small ones were overlooked) and snails.

The most abundant hexapods in every sample have been the Collembola. For the purposes of an introductory course, we have recognized only four families: Hypogas-

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[1]Contribution no. 3106 from the Snow Entomological Museum & Department of Entomology, University of Kansas.

truridae (formerly Poduridae in the broad sense and possibly including some Onychiuridae) (11.4-62.3% of Collembola in a sample; mean 43.5%), Entomobryidae (including Isotomidae) (26.9-79.2%; mean 51.3%), Sminthuridae (1.5-12.2%; mean 5.2%) and Neelidae. Neelids were rare and present only in negligible numbers.

There have been some rather striking fluctuations in the number of Collembola recovered and simultaneously in the total number of arthropods collected. On 23 July 1971, both Collembola and Acarina reached their highest recorded numbers (Table 1), while in the corresponding sample two years later (20 July 1973), Acarina dropped to their lowest level and Collembola to their second lowest. Collembola were lowest in 1984 (sample taken on 16 July).

In 1965 and all subsequent years of sampling at Mountain Lake, I have continued to operate the Berlese funnel throughout the five-week course, often obtaining later samples quite near where earlier ones were taken. So much variation was seen from one of these samples to the next that it was evident the composition of the fauna was very much a matter of the particular site. That is, adjacent samples taken about a week apart could show considerably different faunal characteristics. Consequently, our infrequent samples cannot be relied upon to indicate widespread population levels or trends of change over time (such as effects of acid rain). Numerous samples of random distribution within the area would be required to show these effects. I have not examined in any detail the ecological conditions from one sample site to the next. Neither am I sufficiently acquainted with the biological requirements of the many species of Collembola, Acarina, etc., to know what factors control their numbers or their spatial distribution. Such small, localized differences as presence or absence of a particular food source, more or less humid conditions, differences in soil chemistry, and microclimatic temperature differences possibly related to hours of shade or sun, or to thickness of the leaf-litter, come to mind. Seasonal variation in environmental conditions, such as between June and July samples, surely affects localized faunas, as well as population levels in general. What the samples indicate is that there has been no significant decline in the numbers of individuals of the dominant soil taxa over nearly 30 years (Table 1).

Acknowledgment

I would like to thank Dr. Christine A. Nalepa of North Carolina State University for reading a draft of this paper and making helpful suggestions.

Table 1. Numbers of representative arthropods in soil samples taken in years indicated at Mountain Lake Biological Station, Giles County, Virginia.

Year	Acarina	Collembola	Symphyla	Total, all taxa
1965	2758	3006	63	6171
1967	1553	2250	79	4294
1969	2715	1588	33	4874
1971	4886	5409	180	10895
1973	1082	1288	92	2968
1975	1866	1917	24	4873
1977	1091	1368	175	2998
1979	1238	1774	195	3451
1980	3332	1740	78	5328
1982	2804	1454	100	4685
1984	2960	1255	109	4557
1986	2602	2726	44	5746
1988	1906	1616	166	4164
1990	1329	1991	145	4413
1992	2768	3871	179	7070
	34890	33253	1662	76487

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The Occurrence of *Hemiscolopendra punctiventris* (Newport), an Ecophilous Centiped, in Virginia (Chilopoda: Scolopendromorpha)

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All centipeds possess poison fangs modified from the first pair of legs, and so far as known all are voracious predators. To observe one in the act of capturing and subduing a prey object is to witness the epitomy of mindless frenzy. In many parts of the world the larger species of Scolopendromorpha interface negatively with the human beings they encounter, often inflicting multiple bites for no apparent provocation. In the Southwest Pacific theatre of operations during World War II, many servicemen were hospitalized following envenomation by scolopendrids falling into occupied foxholes. In many tropical cities, large individuals find their way even to uppermost floors of high-rise apartments, there to terrorize the occupants.

In eastern United States, north of Florida, only a few species are large enough to inflict palpable injury upon human beings, and of these, only one regularly enters houses and attacks human residents. This is the colorful blue centiped, *Hemiscolopendra punctiventris* (Newport), which ranges as far north as Virginia and Indiana, chiefly at low elevations. The preferred habitat of this animal is the space beneath loose bark of downed pines, although other fallen trees or their limbs may be utilized on occasion. In Virginia, most specimens show a dorsal pattern of light blue terga with darker lateral margins, with the antennae and legs of the same color. Their body length (in life) of about 90 mm (3.5 inches) provides sufficient bulk to impart a formidable mien. The bite has been described as like that of a bee or wasp, accompanied by local swelling and soreness which may persist for several days. There are no known cases of serious complications from the bite of *punctiventris*.

Virtually nothing has been written about the occurrence of this arthropod raptor in Virginia. The only published record known to me is that of Meinert (1883) for Pennington Gap, Lee County. During the past few decades enough data have accumulated to provide a fairly accurate impression of the territory it occupies, as well as some vignettes of its disposition. The following records reflect a distinctly austral range east of the Blue Ridge and south of the James River with only two exceptions. The species also occurs in extreme southwestern Virginia. All material cited is in the VMNH collection except as otherwise specified (USNM: National Museum of Natural History; MCZ: Museum of Comparative Zoology).

Brunswick Co.: 2.5 mi. (4 km) south of Triplett, 22 June 1960, W. L. Burger. **Campbell Co.**: Lynchburg, Candler Mountain, under board, 10 July 1993, M. S. Hayslett. **Dickenson Co.**: Cranes Nest River, ca 5 mi. (8 km) west of Haysi, 27 April 1962, R. L. Hoffman. **Gloucester Co.**: Gloucester Court House, in home, sent in by county agent. **Henry Co.**: Oak Level, in house, 1 November 1989, B. Wilson; 1 mi. (2 km) south of Martinsville, US Hy. 220, 8 June 1990, R. Mitchell; Martinsville, inside VMNH building, 7 June 1991, N. C. Fraser. **Lee Co.**: Pennington Gap, no date recorded, Hubbard & Schwartz (MCZ). **Mecklenburg Co.**: along Va. Hy. 49 at Nelson P. O., under pine bark, 7 November 1971, R. L. Hoffman & L. S. Knight. **Northampton Co.**: Smith Island, December 1898, W. Palmer (USNM); also 22 September 1988, C. A. Pague. **Pittsylvania Co.**: Camp Shawnee, near Ringgold, 27 June 1993, Lynn Pritchett. **Powhatan Co.**: Provost, jct. Va. Hys. 621 and 684, 24 November 1988, Peggy Palmer. **Prince Edward Co.**: Hampden-Sydney College, 2nd floor Gilmer Hall, June 1990, also 1st floor Gilmer Hall, 5 December 1991, W. A. Shear. **Surry Co.**: Chippokes Plantation State Park, 27 April 1991, K. A. Buhlmann. **City of Norfolk:** residence on Conway Avenue, in bed, A. Thompson (USNM). **City of Virginia Beach**: Seashore State Park, pitfall trap, 1 May 1989, 22 May 1989, 26 July 1989, all VDNH survey, also under pine bark, 8-13 June 1970, R. L. Hoffman, also "Virginia Beach" 7 October 1901, W. Beutenmüller (USNM).

The USNM collection has two specimens ostensibly found at Luray, Page Co., by L. M. Underwood. This locality is biogeographically implausible and may be the result of mislabeling. Unless confirmed, Luray must be considered outside the natural range of the species.

The most interesting incontestable record is that for Smith Island, on the northern side of the Chesapeake estuary. Overwater dispersal by floating pine trunks or

branches affords a plausible explanation for this occurrence. Possibly *punctiventris* enjoyed a more extensive northern distribution during the Hypsithermal Interval (ca. 3,000–9,000 YBP), which would implicate the Smith Island population as relictual.

The distribution of the species in North Carolina has been thoroughly documented by Shelley (1987, Fig. 11), who found it essentially statewide east of the Blue Ridge. *H. punctiventris* is not uncommon in south-central Virginia and can usually be found as desired. Curiously, in Virginia Beach, where the Virginia Division of Natural Heritage conducted numerous pitfall sampling stations over a period of two years, only one or two specimens were obtained. By contrast, dozens of individuals of the equally large *Scolopocryptops sexspinosus* (Say) (family Cryptopidae) were captured at each locality. One initial explanation of this disparity suggests that *sexspinosus*, is prone to forage on the surface at night (and so tumble into pitfalls), in contrast to *punctiventris* which is at least somewhat arboreal and perhaps more inclined to search for its provender under bark.

That the species is surface active is implicit in the frequency with which it enters houses, a trait not peculiar to Virginia. Dr. J. C. Morse recently showed me the material of this species in the Clemson University collection, most sent in for identification, from which the following documentation was copied (all specimens from South Carolina): Cherokee Co., "household"; Edgefield, "in residence"; Elloree, "inside house"; Sixmile, "in house"; Chester, "in shoe under bed, bit child."

Dr. Shear advises me that he was once bitten on the calf by a specimen which entered his ground-level apartment, crossed the room, ascended his leg inside his trousers, and bit him without evident provocation. In the summer of 1993, a resident of Collinsville, Virginia, brought in a *punctiventris* which had fallen into his wife's hair while she was lying in bed (apparently it was on the ceiling) and bit her scalp during its removal. The pain was described as similar to that of a honeybee sting. Dr. Shelley informed of a bite inflicted on the eyelid of a woman at Raleigh, N. C., who was awaken by a *punctiventris* crawling across her forehead. Pain and topical swelling persisted for several hours after the injury.

Despite the apparent difference in surface activity as reflected by pitfall captures, I have no knowledge of any *S. sexspinosus* ever entering a house, or biting anyone, although the species is just as large as *punctiventris* and as capable of inflicting injury. Is the answer as simple as the latter being more adept at avoiding pitfalls? Perhaps it is a characteristic of all species of Scolopendridae to be more tolerant of dry situations, and thus able to wander into buildings, in contrast to even the largest species of Cryptopidae which avoid such situations?

Acknowledgements

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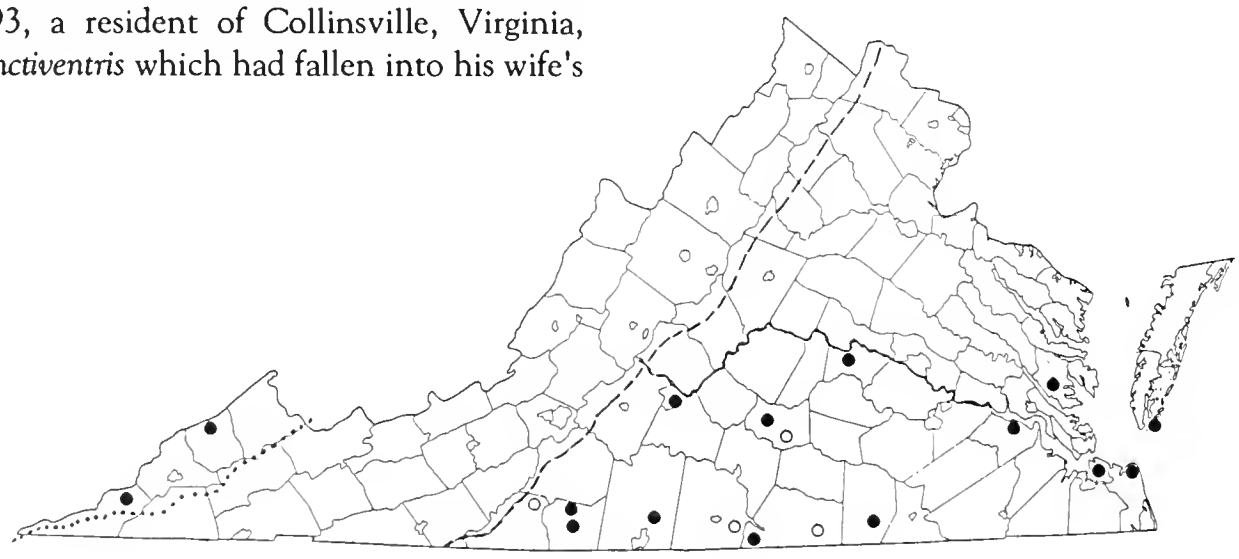

Figure 1. Distribution of *Hemiscolopendra punctiventris* in Virginia. The dashed line shows the eastern edge of the Blue Ridge, and the dotted line the eastern edge of the Appalachian Plateau province. The course of the James River across the Piedmont is highlighted. Several sight or anecdotal records are shown by open circles.

Miscellanea

First Meeting of the Virginia Natural History Society

The First Annual Meeting of the Virginia Natural History Society will be held on 19 May 1994 at James Madison University, Harrisonburg, VA in conjunction with the Virginia Academy of Science. The VNHS has organized a new section entitled "Natural History and Biodiversity." Additional information may be obtained from the Section Secretary (and VNHS Vice-President) Dr. C. Barry Knisley, Department of Biology, Randolph-Macon College, Ashland, VA 23005 (804-752-7254). Information about the meeting in general may be obtained from the Virginia Academy of Science, Dept. of Biology, University of Richmond, VA 23173.

Wintergreen Natural History Weekend

The fourth Natural History Weekend will be held at Wintergreen Resort on 16-18 September 1994. This event is similar to their Wildflower Weekend held in May, with a series of lectures and field trips given by the scientists conducting field research in Virginia. In 1993, there were 21 field trips and 15 slide lectures and workshops given in areas ranging from archeology to geology to botany and vertebrate zoology by 14 Virginia scientists and natural historians. The goal of these events is to offer teachers and the interested lay public an opportunity to meet and interact with people who are doing natural history research in the Commonwealth and to demonstrate the wealth of natural history opportunities found here. Friday evening includes an overview of the weekend's events and a means of meeting the speakers and field trip leaders. A special presentation is held on Saturday evening and this year's event may include a book signing by several authors of recently-published books on Virginia's natural history. Registration in 1994 will be $60 ($50 for VA Museum of Natural History members) that includes all events. Accommodations are estimated at $71 per night double occupancy ($36 each person). This event offers recertification credits to Virginia secondary school teachers and is a way to learn some of the results of recent research before they are published. Information may be obtained from Doug Coleman, Wintergreen Resort, P.O. Box 906, Wintergreen, VA 22958 (804-325-7852, ext. 865).

Appalachian Biogeography Symposium

The first symposium on Appalachian Biogeography was held in 27-29 June 1968 and resulted in three volumes covering the flora, invertebrates, and vertebrates of the region. A second symposium on this topic is being organized for 25–29 June 1995 by Ralph P. Eckerlin and others that will update our understanding of the varied biogeographical relationships of the Appalachian Mountains published in the first series. Papers are being sought on botany, geology, invertebrate biology, paleobiology, paleoclimatology, physical geography, and vertebrate biology. People interested in presenting papers or posters should submit titles to Dr. Eckerlin, Natural Sciences Division, Northern Virginia Community College, 8333 Little River Turnpike, Annandale, VA 22003-3796 (703-323-3234, FAX 703-323-3215) by 15 March 1994. If you are interested and have not sent in a title by this date, contact him for the current status of the list of speakers. The proceedings of the symposium will be published.

Editorial Announcements

Banisteria is expanding the range of articles contained in its pages. The editors solicit manuscripts detailing the biographies of people who have contributed to the natural history of Virginia. These articles could contain exhaustive descriptions of the person's life and accomplishments, his or her contributions to the natural history of the Commonwealth or to the scientific discipline, photographs, and lists of publications. There are few places where historical information is published regarding our colleagues who have worked in the state, and we envision that *Banisteria* could fill a long-standing void.

In addition, the editors of *Banisteria* are seeking book reviews from anyone who wishes to describe and critique books related in some way to the natural history of Virginia. We are also seeking essays on current issues or controversial subject pertaining to natural history. Essays can be of any length. The editors reserve the right to seek additional essays on the topic in question so that more than one view can be published. Essays can also be submitted in the form of "letters to the editor."

Biographical manuscripts, book reviews, essays, and letters to the editor should be sent to Joseph C. Mitchell, Department of Biology, University of Richmond, Richmond, VA 23173.

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Information on upcoming meetings, symposia, and other events of interest to members of the Virginia Natural History Society should be sent to the editors.

Instructions for Contributors

Banisteria accepts manuscripts of one or more pages in length that contribute to the public and scientific knowledge of the natural history of Virginia. This publication is intended to be an outlet for information which, although of considerable local interest, might not be accepted in the mainstream journals of many disciplines. Unpublished information and data accumulated in field notebooks and files are especially solicited. The focus of *Banisteria* is classical, biased toward organismal biology. Advance communication with an editor will resolve questions about length and suitability of manuscripts.

Manuscripts should be submitted in photocopy triplicate to one of the co-editors, who will arrange for appropriate peer review. Authors should retain both the original typescript (and diskette) and figures until notified of final acceptance and the opportunity to consider reviewer's comments.

The Manuscript

Manuscripts should be written on one side of standard-size typing paper using double spacing throughout. Do not hyphenate words (set word processor for unjustified right margins).

Organize the paper in the following order: title, author's name, author's address, text, acknowledgements, literature cited, tables, figure legends, figures. Abstracts are not used, but an equivalent summary section may be added at the end of the text. Standard sections (e.g., Materials, Methods, Results, Discussion, &c), may be appropriate for long papers. Consult a recent issue of *Banisteria* as a model to follow in formatting. Scientific names should be underlined or italicized; do not format type with other codes (e.g., bold, small caps, etc.). Do not use footnotes except where absolutely required.

References: Use the following as a guide. Spell out journal names in full.

Journal article with 1 author:
Scott, D. 1986. Notes on the eastern hognose snake, *Heterodon platyrhinos* Latreille (Squamata: Colubridae), in a Virginia barrier island. Brimleyana 12:51-55.

Journal article with 2 authors:
Tilley, S. C., and D. W. Tinkle. 1968. A reinterpretation of the reproductive cycle and demography of the salamander *Desmognathus ochrophaeus*. Copeia 1968: 299-303.

Journal with 3 or more authors:
Funderburg, J. B., P. Hertz, and W. M. Kerfoot. 1974. A range extention for the carpenter frog, *Rana virgatipes* Cope, in the Chesapeake Bay region. Bulletin Maryland Herpetological Society 10:77-79.

Book:
Harris, L. D. 1984. The Fragmented Forest. University of Chicago Press, Chicago, IL. 211 pp.

Chapter in a book:
Gentry, A. H. 1986. Endemism in tropical versus temperate plant communities. Pp. 153-181 *In* M. Soule (ed.), Conservation Biology. Sinauer Associates, Inc., Sunderland, MA.

Report:
The Nature Conservancy. 1975. The preservation of natural diversity: A survey and recommendations. Report to the U.S. Dept. of Interior, Washington, D.C., 189 pp. (include report series and number if present)

Tables: Each table should be typed on a separate sheet of paper. A legend for each table should follow the number and must be on the same page as the table. Ruled, horizontal lines should be avoided except at the top and bottom of the table.

Illustrations: Black-and-white line drawings and high contrast black-and-white photographs are acceptable for publication. The back of each illustration should be labeled with the author's name. Indicate desired placement with pencil in text margin.

Abbreviations: The following are common abbreviations accepted in *Banisteria*:
x (mean), n (sample size), no. (number), SVL (snout-vent length; define on first usage), yr (years), mo (months), wk (weeks), h (hours), min (minutes), s (seconds), P (probability), df (degrees of freedom), SD and SE (standard deviation and standard error), NS (not significant), l (liter), g (grams), mm (millimeter), C (degrees Celcius). Do not abbreviate "male" or "female", or dates, or undefined terms.

Electronic transfer of manuscripts: Once a manuscript has been accepted for publication, one paper copy of the revised version and an electronic copy on 5.25" or 3.5" diskette should be sent to R. L. Hoffman at the Virginia Museum of Natural History. If possible, use IBM-compatible (MS-DOS) systems with Word Perfect version 5.1 or later.

Reprints: Reprints are not provided. However, an author may photocopy his own article for personal use.

Chrysogonum virginianum Linnaeus

Original drawing by John Banister. Figure 83 in folio in Hans Sloane's MS 4002 in the British Museum. Photocopy courtesy of Joseph and Nesta Ewan.